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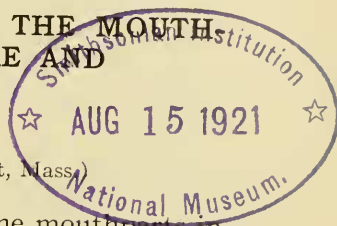
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THE SCLERITES OF THE HEAD, AND THE MOUTH-
PARTS OF CERTAIN IMMATURE AND
ADULT INSECTS.

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The external structures of the head, and the mouthparts in particular, are of considerable interest in making a study of the interrelationships and lines of descent of the different orders of insects; and it is of the greatest importance, in such a study, that we should know the correct homologies of the various parts, in order to determine what paths of development have been followed in deriving the higher types of insects from the lower ones. Many investigators have made the mistake of attempting to compare the higher types directly with the lowest ones without tracing the development of these types through a series of intermediate forms, with the result that the interpretations generally accepted as correct are frequently quite the reverse, and the true meaning of the different structures has not been fully grasped in many instances. On this account, I would devote the greater part of the following discussion to the consideration of such intermediate types as the Coleoptera, Neuroptera, etc., which serve to connect the lower insects with the higher ones, since it is these intermediate forms alone which can furnish us with the key to the proper interpretation of the modifications of the parts met with in the higher forms. Consideration has also been given to the condition found in larval insects as well, for, although larval insects are usually modified in adaptation to their own peculiar environmental conditions, they frequently retain the head structures in a more primitive condition than their



corresponding adults do, and the clues obtained from an examination of the larval structures have amply justified the time spent in their study.

Dr. F. C. Craighead has very generously permitted me to incorporate his observations on the musculature of the mouthparts of an adult and larval *Corydalid* in this paper, and Figures 11 and 14 of Plate III were drawn by him. Since the advance information which he has kindly permitted me to use, has not yet been published by him, I would emphasize the fact that the statements concerning the musculature of the mouthparts quoted in this paper should be accredited to him, as is indicated where such quotations have been made in the following discussion.

Through the kindness of Mr. Nathan Banks, I was able to examine a number of interesting insects in the Harvard Museum, and many of the drawings of the heads of Neuroptera were made from this material. Since the specimens were dried, however, it was not always possible to see all of the parts very clearly, and many of the drawings from this source are therefore rather diagrammatic. I am also indebted to Dr. Edna Mosher for the loan of a *Hepialid* larva, to Dr. Cornelius Betten for the identification of the trichopterous larvæ here figured, and to Dr. Needham and Dr. Tillyard for some extremely interesting and valuable neuropterous larvæ.

The principal papers dealing with the mouthparts and head structures of insects in general are those of Packard, 1882-1898; Chatin, 1884-1897; Waterhouse, 1895; Kellogg, 1902-1904; Comstock and Kochi, 1902; Verhoeff, 1904; Berlese, 1909; Crampton, 1916-1917, and Yuasa, 1920. Hosford, 1918, has also treated of the head structures of insects in general; but her paper is practically a review of Comstock's work. Peterson, 1916, has recently written a fine paper on the head structures of Diptera, comparing them with the head structures of Orthoptera; but unfortunately he did not make a study of intermediate forms connecting such primitive types as the Orthoptera with such highly specialized types as the Diptera, with the result that certain of his interpretations of the parts in Diptera are quite wrong, and other investigators such as Wesche, who have attempted to compare the structures of Diptera directly with those of Orthoptera, have fallen into the same error.

Despite the fact that a large number of papers have been published dealing with the head structures of insects, the boundaries of the various head sclerites have not in many instances been clearly defined; and in the higher insects, such as the Diptera, the parts of the labium, for example, have not been interpreted correctly in the recent papers dealing with the subject. Even the most basic and fundamental features of the composition of an insect's head are not understood and interpreted aright in most of the recent textbooks and articles which treat of this phase of the subject, and it is quite apparent that there is a decided need of a thorough-going review of the whole subject of the head region of insects and the interpretation of its parts. Thus, for example, everyone who has recently discussed the superlinguæ or "paraglossæ" of insects (i. e., the lobes on either side of the hypopharynx) homologizes them with the maxillulæ (first maxillæ), instead of with the *paragnaths* of Crustacea, as should be done. (See references to origin of superlinguæ, mandibles, maxillæ, etc., in bibliography). In most textbooks one sees the incorrect statement that the maxillary galea and palpus represent the two forks of a biramous limb, instead of the correct interpretation of the palpus as the distal segments of a limb (endopodite) in which the second or stipes segment, and the third or palpifer segment have developed endites or lobe-like processes forming the galea and lacinia. The statement that the parts of the maxillæ are represented in the mandible, which one encounters in many publications, is wholly incorrect, since the mandible represents but a single segment of a limb, while the maxilla is composed of more than one segment of such a limb. The statement that the head of an insect is composed of seven segments, instead of but six (as embryology has long shown to be the case) is another instance of the many glaring inaccuracies one encounters on every hand in reading the literature dealing with the head region of insects; but since these matters have been discussed more at length in a series of articles dealing with each phase of the subject in detail, the following discussion is restricted to an attempt to determine the boundaries of the sclerites of the head in insects in general, and to interpret the structure of the parts of the head of higher insects in terms of those of the lower forms by using for study, as far as possible, the intermediate types serving to connect the higher with the lower insects.

As the study of embryology indicates, six segments enter into the composition of an insect's head. These are the protocephalon, antennal segment, intercalary segment, mandibular segment, first maxillary segment, and second maxillary or labial segment. Janet, 1899, Berlese, 1909, and others who profess to be able to mark off the head capsule of adult insects into rings of sclerites corresponding to the embryonic segments entering into the composition of the head, have simply let their imagination run away with them, and the diagrams which they have constructed do not correspond to the facts at all, for, as embryologists such as Riley, 1904, have pointed out, "the definitive sclerites can afford us little or no evidence as to the primary segmentation of the insects." It is therefore preferable to describe the sclerites of the head with reference to certain "landmarks" which occur in most insects, rather than to attempt to divide the head capsule into rings corresponding to the original segments entering into its composition. It must be borne in mind, however, that these convenient "landmarks" for establishing the boundaries of the head regions are not present in all insects; and in some forms, the sutures, etc., which occur in the lower insects may become obliterated and new ones may be formed, thereby tending to mask the original condition, and making it very difficult to define the regions with any great accuracy throughout the series of insects. In such cases it is often impossible to do more than state that the secondarily formed region is equivalent to the original one only in a general way.

The upper lip or *labrum*, (labeled "1" in all Figures) together with the clypeus, frons, "vertex," and genæ, all arise from the first or proto-cerebral segment of the embryo, according to Riley, 1904; and the labrum has been compared to the prostomium of annelids by some investigators, although there is some doubt as to the exactness of the homology in the latter case. The anterior (or lower) margin of the labrum is so deeply incised in some insects, as to give the labrum a pronounced bilobed appearance, which has led certain entomologists to conclude that the labrum is the fusion produce of two appendages; but a study of the embryological development of the labrum has shown that this view is entirely fanciful and unfounded. The labrum extends posteriorly to the transverse *labral suture* which usually demarks the labrum from the clypeal region behind it, although the labral suture is obsolete in some insects. When the labrum and clypeus are viewed from the "inner" or buccal surface, a small hinge-like thickening called the *torma* by Peterson, 1916, may be observed near either end of the labral suture, at the junction of the labral and clypeal regions; and these tormæ are frequently of value in determining the posterior boundaries of the labrum.

The labrum may be long and narrow as in certain Diptera, etc., or it may be broader than long, as in the orthopteroid insects. In some Hymenoptera, the labrum is not distinct, and a membranous lobe-like region called the *epipharynx* may project from the anterior region of the mouth to close the base of the tube for sucking honey, etc. In

certain Diptera, the epipharynx may become long and stylet-like, forming with the labrum, the so-called labrum-epipharynx. In the orthopteroid insects the epipharyngeal region usually does not project to any great extent, and in such cases consists of the membranous inner lining of the labrum and clypeus (i. e., the "roof of the mouth") bearing hairs and taste organs frequently arranged about a Y-shaped thickening near the median region. In certain of these orthopteroid insects, the labrum may be partially divided into an anterior and posterior area called the *antelabrum* and *postlabrum*, by an incomplete transverse suture or by emarginations of the sides of the labrum.

As was previously mentioned, Riley, 1904, considers that the clypeus, together with the labrum, frons, etc., arose from the first or protocerebral segment of the embryo. The *clypeus*, labeled "cl" in all Figures, extends from the labrum (or the labral suture) posteriorly to the *clypeal suture*, which, however, may be obsolete in some insects. When the clypeal suture has disappeared, the posterior limits of the clypeus are demarked by a line drawn across from the base of one mandible to the base of the other mandible, since the clypeal suture, when present, corresponds in general to such a line connecting the bases of the mandibles, which are therefore the chief "landmarks" delimiting the posterior extent of the clypeus. This fact is of considerable importance, since the area usually called the clypeus in the Psocidæ, etc., lies behind the line connecting the bases of the mandibles, and is therefore in all probability an anterior portion of the frontal region.

The entire clypeal region may be but slightly chitinized and pigmented, giving the appearance of a membranous area, as is the case with the region labeled "cl" in Fig. 79 of a larval Lepidopteron, or in Fig. 39, of the termite *Mastotermes*. In other instances, as is the case in the Neuropteran *Raphidia*, shown in Fig. 33, and less clearly in the earwig shown in Fig. 36, the posterior region "pc" of the clypeus may be strongly chitinized and pigmented, while the anterior region "ac" is not strongly chitinized and pigmented (i. e., has a membranous appearance) thus differentiating the entire clypeal region into an *anteclypeus* "ac" and a *postclypeus*, "pc." Occasionally, the clypeus is divided into an anteclypeus and a postclypeus by a transclypeal suture extending transversely across it.

In the larva of the Neuropteran *Sialis*, shown in Fig. 40, the clypeal region "cl" is retained in a condition more nearly approximating the primitive, or original one. If one will compare this larva with those of the Neuroptera *Raphidia* and *Corydalus*, shown in Figs. 41 and 42, one may see that while the clypeal suture extends clear across from the base of one mandible to the base of the other in the larval *Sialis* shown in Fig. 40, (i. e., the line of the posterior border of the area "cl" extending from the base of one antenna to the other) this same clypeal suture is broken or interrupted in the larvæ shown in Figs. 41 and 42. In other words, the clypeal suture, usually extending from the base of one mandible to the other, extends only from the base of the antenna labeled "bat" to the frontal pit "fp" on either side of the head of the larvæ depicted in Figs. 41 and 42, while the median portion of the

clypeal suture has "faded out," leaving no line of demarcation between the regions "pc" and "fr." Anterior prolongations of the arms of the frontal suture "fs" have extended forward into the clypeal region and have marked off a *paraclypeal* or *lateroclypeal* region "pcl" on either side of the median region of the postclypeus "pc." Comstock and Kochi, 1902, call the paraclypeal regions "pcl" the "antecoxal pieces of the mandibles;" but they are no more closely associated with the mandibles than are the lateral regions of the clypeus in any other insects, and the *clypanguli* or postero-lateral angles or lobes of the clypeus, which frequently bear the articulatory areas with which the dorsal condyles (epicondyles) of the mandibles articulate, are very much the same in *Raphidia* (Fig. 41), as they are in any other insect. The antero-ventral arms of the tentorium frequently extend forward to a point at or near the clypanguli. In the water bug *Belostoma* (Fig. 76) the lateral areas labeled "pcl?" which are here referred to as the jugum, (following a suggestion by Dr. Parshley) are possibly homologous with the paraclypeal areas of the Neuropterous larvæ shown in Figs. 41 and 42, "pcl;" but this point has not been definitely established.

Like the labrum and clypeus, the frons is a median unpaired region of the head (the posteriormost of the dorsal unpaired areas), and it also, according to Riley, 1904, arose from the protocerebral segment of the embryo. The frons, labeled "fr" in all Figures, extends from the clypeal suture (or a line drawn between the bases of the mandibles) to the *frontal suture*, labeled "fs" in Figs. 32, 36, etc., the frontal suture, when present, serving to demark the frontal region. When the frontal suture is absent, if a line be drawn across from the top of one antennal fossa to the other, and at either end of this line an angle of forty-five degrees is constructed the sides of the isosceles triangle thus formed, correspond in a general way to the frontal suture, which is formed by the arms of the Y-shaped epicranial suture (i. e., "cs" and "fs" of Figs. 32, 36, 40, etc.) when the latter is present. The frons usually includes the area bearing the *median ocellus*, but this is absent in many insects.

The frontal suture "fs" may extend forward "inside" of (or mesal to) the bases of the antennæ, as in Fig. 32 (a condition typical of many larval insects); or it may extend "outside" of (lateral to) the bases of the antennæ, as in the earwig shown in Fig. 36. In most larvæ (Figs. 32, 40, 79) the frontal suture extends to the epicondyle, or dorsal condyle of the mandible, and this is also true of many of the adult Neuroptera here figured, although in the latter insects, only the anterior portions of the frontal suture are retained, for the most part. A pair of *frontal pits* ("fp" of Figs. 63, 70, 42, etc.) or external manifestations of the internal invaginations of the body-wall forming the antero-dorsal arms of the tentorium, occur on or near the frontal suture in many Neuroptera, etc.

As was mentioned before, the frontal suture may secondarily send down branches into the clypeal region (marking off the lateral areas labeled "pcl" in Figs. 41 and 42), while the median portion of the postclypeal region "pc" unites with the frons "fr" to form a compound

frontoclypeal region bearing the labels "fr" and "pc" in Figs. 41 and 42, although the original extent of the frons "fr" is retained in the insect shown in Fig. 40.

A line drawn across between the bases of the antennæ divides the frons into an *antefrons* and *postfrons* in certain insects, and in these forms, the postfrons is usually united with the upper region of the head capsule. A narrow transverse region called the *epistoma* "eps" of Fig. 38, becomes secondarily marked off in the anterior region of the frons of certain beetle larvæ, etc., and in certain sawfly larvæ, such as the one shown in Fig. 32, a region labeled "eps," which may correspond to a portion of the epistoma is marked off by a faintly impressed line. MacGillivray, 1913, refers to the region "eps" of the sawfly larva shown in Fig. 32, as the "first clypeus," and to the true clypeus "pc" and "ac" as the "second clypeus." The region "eps," however, is clearly a portion of the frons, since it lies behind the clypeal suture extending across from the base of one mandible to the other, and while the region labeled "eps" in Fig. 32 does not correspond to the entire area bearing the label "eps" in Fig. 38, it does in a way correspond to the epistoma, or to a portion of the epistoma, and may therefore be regarded as a greatly reduced epistoma.

It is possible that the area labeled "fr" in Fig. 76 represents the anterior region of the frons (antefrons) rather than the frons proper, although for the sake of convenience, it has been referred to simply as the "frons" in the following discussion. In the Psocidæ (sensu lato), however, the region usually referred to as the "frons" is clearly the antefrons (or anterior region of the frons) alone, while the posterior region of the frons in these insects is frequently indistinguishably united with the region of the head behind it.

The frons was spoken of above as an unpaired region of the head, and this is true of most insects. In the beetle larva shown in Fig. 38, however, a median dorsal infolding or "implex" of the head capsule is formed, resulting in the production of an internal ridge for muscle attachment, and an external suture (corresponding to the internal ridge) which extends forward into the frontal region "fr," dividing it into equal halves,* as is shown in Fig. 38.

If we adopt from vertebrate anatomy the term "frontal region" for the frons, and the term "occipital region" for the portion of the head capsule about the occipital foramen, it is but logical to call the region between the frontal and occipital regions the "parietal region," since the parietal region occupies this position in the vertebrate skull. The term "parietals" has therefore been adopted for the region between the frons and occiput (i. e., the region labeled "pa" in all Figures) in the following discussion. Some entomologists apply the term epicranium to the parietals; but properly speaking, the epicranium includes not only the parietals, but also the frons, genæ and postgenæ as well, and it is preferable to have a distinct designation for the parietals.

*It is quite probable that the region labeled "fr" in Fig. 38 represents the post frons, rather than the entire frons, since it lies behind the antennæ (in the postfrontal region).

The term vertex has also been applied to the parietals, and while this term is quite suitable for the parietal region of the Orthopteroid insects, in which the parietal region occupies the upper portion of the head, in other insects, such as the lepidopterous larva shown in Fig. 79, in which the parietals extend far forward, the term vertex is wholly inapplicable for the region in question, and in order to have a suitable term for this region in all insects, and since the sclerites composing this region are *paired*, it is preferable to refer to the sclerites between the frons and occiput as the parietals, as is done in vertebrate morphology.

The stem of the Y-shaped *epicranial suture* "cs" and "fs" forms the *midcranial* or *coronal suture* "cs" dividing the parietal area into symmetrical parts, and it is usually along this suture that the integument of the insect splits at the time of molting. The coronal suture "cs" is likewise an anterior continuation of the middorsal suture along the median region of the back, along which the integument of the body in general is split at the time of molting, thus suggesting a Lamarckian explanation of the origin of the suture in question. Comstock and Kochi, 1902, state that the middorsal suture "represents the line of closure of the embryo." While this suture may coincide with the line of closure of the embryo, I am inclined to consider that the middorsal suture (and its continuation into the head region as the coronal suture "cs") in some cases owes its origin to an infolding of the integument for muscle attachment. In the head region there is frequently a median dorsal "implex" or endoplica formed by an infolding of the integument for muscle attachment, and the lips of such an infolding of the body wall form an external suture.

In certain lepidopterous larvæ, as in the one shown in Fig. 79, an infolding of the integument occurs on either side of the frontal region "fr," and the *frontal sutures*, formed by the lips of these infoldings or endoplicæ, together with the *adfrontal sutures* mark off an adfrontal area (the *adfrontals* "af") on either side of the frons. In the beetle larva shown in Fig. 38, there are also marked off on either side of the region labeled "fr" (which represents a posterior portion of the frons) areas resembling the adfrontals "af" of the Lepidoptera (Fig. 79); the sclerites labeled "af" in Figs 38 and 79, and although the regions are not precisely the same in both insects, may be referred to as the adfrontals, for the sake of convenience.

On either side of the frons "fr" of various Neuroptera (e. g., Figs. 45, 56, 70, 74, etc.) there occurs a *parafrontal region* or *parafrons*, "pf," usually situated between the frontal suture (or the frontal pits "fp") and the compound eyes. The parafrontals are therefore somewhat different from the adfrontals described above, and have been designated by another term, to indicate this fact.

As was pointed out in a paper on the head region of lower insects (Crampton, 1917) a "*paracephalic*" or *laterocephal* suture marks off a laterocephalic area on each side of the head capsule, in some of the lower forms, though these areas may possibly represent secondarily

formed regions of no particular phylogenetic significance, since they are not demarked in all of the primitive insects.

The anterior portions of the laterocephalic regions, namely, the areas below and behind the compound eyes, forming the "cheek" regions of the head, are called the *genæ*. An approximately vertical ridge or suture frequently demarks a posterior region of the *genæ* called the *postgena* by Comstock and Kochi, 1902. When these *postgenæ* extend along the gular region of the head, they correspond in a way, to the paragular region and hypostoma, described under the discussion of the ventral surface of the head capsule.

At the base of the mandibles (below, or anterior to the *genæ*) is a small sclerite called the *basimandibula* ("bmd" of Fig. 39) in the article referred to above (Crampton, 1917). This sclerite probably owes its origin to the chitinization of a portion of the membrane between the mandible and the head capsule. Comstock and Kochi, 1902, call the sclerites "bmd" (Fig. 39) the "trochantin of the mandible," thinking that it represents the trochantin or small sclerite at the base of the thoracic legs. This homology, however, is entirely fanciful, and it is misleading to designate the sclerite in question as the "trochantin" of the mandible.

Comstock and Kochi, 1902, describe an *ocular sclerite* surrounding the compound eyes; but I am inclined to consider that this area is not marked off by a true suture, and I am very sure that it does not represent the basal segment of an ocular appendage as Comstock and Kochi, 1902, are inclined to believe. There is, however, in certain lower insects, a fairly well demarked sclerite at the base of the antenna, called the *antennale* in a previous paper (Crampton, 1917); and a process or projection of this region called the *antennifer* in the paper in question (i. e., the structure labeled "anf" in Fig. 39), frequently supports the antenna in the more primitive insects. At the base of the antenna of many larval insects (particularly those of Coleoptera and Neuroptera) a ring-like area called the *basantenna* ("bat" of Figs. 41, 42, etc.) occurs at the base of the antenna. This area may originate as a projection of the head capsule, or through the chitinization of a portion of the membrane at the base of the antenna, and I am inclined to account for its origin in either of these ways, although this sclerite is regarded as a modified basal segment of the antenna by some entomologists.

Areas called the *postcranial regions*, or the *postcranials* (Crampton, 1920) occur in the posterior portion of the head of certain Trichoptera, etc. Traces of these regions are also found in the lower Lepidoptera, such as the Micropterygids, etc., but I have not traced them through a series of the more primitive representatives of the higher insects, though they will doubtless be found in other orders as well.

The *occiput* labeled "ocp" in all Figures is the dorsal and lateral region about the *occipital foramen*, or posterior opening of the head capsule through which the gullet, nerve cord, etc., pass into the head region. A posterior extension of the midcranial suture "cs" divides the occiput into two parts in the larva of the Neuropteran *Corydalus* (Fig. 42), and in the beetle larva shown in Fig. 38, the occiput consists

of two *occipitals* "ocp" separated by a deep incision. The membranous area occupying the region between a similar incision in the posterior region of the head of the caterpillar shown in Fig. 79, and the anterior edge of the pronotum, is called the *vertical triangle* by Fracker, 1915.

In the postero-lateral region of the head, there frequently occurs a narrow area called the *trophifer* (Crampton, 1917) since the mouthparts articulate with this region in the lower insects. The *maxillifer* (or "*maxillary pleurite*" of Comstock and Kochi, 1902) enters into the composition of this region, and Riley, 1904, states that a portion of the postgena together with the "*maxillary pleurite*" arises from the maxillary segment, while the remainder of the postgena and the sclerites at the base of the mandibles arise from the mandibular segment of the head. It is very strange that if the basimandibulæ "bmd" of Fig. 39 belong to the mandibular segment, the genæ immediately above them do not belong to this same mandibular segment (Riley attributes the genæ to the protocerebral or first primitive segment of the head) and I am not entirely convinced of the correctness of Riley's conclusions in this matter, especially since he wrongly ascribes the cervical sclerites to the labial segment. Riley does not state to which embryonic segment the occiput belongs; but since the occiput occupies a considerable portion of the hinder region of the head, it is quite probable that it is derived from both the maxillary and labial segments.

According to Comstock and Kochi, 1902, the occiput is continued ventrally in the postgenæ, but in certain insects having a well defined occipital region (as in the neuropterous larvæ shown in Figs 14 and 15) the occiput extends ventrally to the gular region "gu." In the beetle shown in Fig. 17, it would appear that the occiput "ocp" is secondarily marked off by the rubbing of the prothoracic parts into which the hinder portion of the head is received in these insects.

The mandible articulates ventrally (by means of the hypocondyle, or ventral condyle labeled "hc" in Fig. 14, etc.) with a region called the *hypostoma*,* labeled "hs" in all Figures. The hypostoma "hs" is an antero-ventral region of the head (a portion of the region called *postgena* by Comstock and Kochi, 1902) situated on either side of, or near, the submentum "sm" (Figs. 15, 17, 18, 9, etc.), and is frequently demarked by a *hypostomal ridge* (or *suture*). Its chief distinguishing feature, however, is the fact that it bears the area with which the ventral condyle of the mandible articulates. In many insects it also bears a "fossa" in which the condyle of the maxilla articulates.

The *paragula* is a region on either side of the gula, labeled "pgu" in all Figures, and is demarked laterally by the paragular ridge or suture. The paragular area is indicated by the shaded area "pgu" (in Figs. 31, 13, 6, 7, 10, etc.) and forms the postero-ventral region of the head on either side of the gula "gu." The paragula and hypostoma together

* This region in larval Cleridæ is discussed by Boving and Champlain in the Proceedings of the U. S. Nat. Museum, Vol. 57, p. 575, 1920, in which a discussion of the mouthparts of Coleoptera in general are also given. The term paragula is also employed in this paper.

make up the region called the postgena by Comstock and Kochi, 1902, the hypostoma forming the anterior portion near the mouth, while the paragula forms the posterior portion of the postgena. It has seemed advisable to thus divide the postgena, since the hypostoma in particular is of importance in the study of the head structures of larval Coleoptera, Neuroptera, etc. In the beetle larva shown in Fig. 27, a small sclerite "pgu?" situated on either side of the gula "gu," and bounded posteriorly by a paragular suture, has been provisionally homologized with the paragula of other insects, although it very probably represents merely an anterior portion of the entire paragula. The divided areas labeled "pgu" in Figs. 22 and 29 are likewise not strictly homologous with the paragulae of other insects, but it is not worth while to designate them by a distinct designation, since they occupy approximately the position of the paragular areas.

The throat region, or the median postero-ventral area of the head, labeled "gu" in all Figures, is called the *gula*. The gula "gu" extends from the posterior border of the head capsule proper to the submentum "sm" (Figs. 12, 16, 15, 18, etc.) and is bounded laterally by more or less distinct lines or sutures called the *gular sutures*. Situated on or near these sutures are the *gular pits* "gp" of Figs. 15, 12, 9, etc., which mark the position of the posterior ventral arms of the tentorium. In some insects, the gular pits mark the posterior extent of the submentum, but in others, the gular region extends far forward of these gular pits (as in Fig. 12). In such cases, the anterior extent of the gular region is marked by a line drawn between the bases of the maxillary cardines "car" (corresponding to the submental suture), or, according to Dr. Craighead, the gular region extends forward to the posterior attachment of the muscles labeled "11" in Figs 11 and 14.

The *intersternite*, "is" of Figs 8, 15, 13, etc., one of the anterior plates of the neck region, is ascribed to the gular region by Comstock and Kochi, 1902, Riley, 1904, and others; but this plate becomes attached to the posterior region of the head in very few insects, and then only secondarily. It is homologous with other intersegmental plates occurring between the thoracic segments in the lower insects, as was pointed out by Crampton, 1917. The *pregula*, "prg" of Fig. 17, is apparently a region secondarily marked off in front of the narrow region of the throat labeled "gu" in certain Coleoptera, etc. Its significance is not very clear, and there is need of further study of this region.

In the insects shown in Figs. 20, 21, 24, 26 and 27, the region labeled "gu" may not represent the entire gula, and has therefore been referred to as the *gular plate* in the following discussion. The region labeled "gu" in Fig. 7, likewise may not represent the entire gular region, but such a narrow, transverse, posterior gular plate is characteristic of the Dermaptera, and may serve as one of the diagnostic characters of the order.

The origin of the gular region is a very puzzling feature. It is quite possible that in some insects the posterior portion of the gular region of the adult head may be formed through a chitinization of the membranous area situated between the ventro-median edges of the head

capsule and behind the mentum. In the insect shown in Fig. 27, it would appear that the ventro-median edges of the head capsule have become approximated, or "come together," behind the narrow gular plate "gu," and meet along the *midgular suture* "mgs." The fact that there is a narrow membranous space behind the gular plate "gu" in the trichopterous larva shown in Fig. 20, while this space has apparently disappeared through the coming together of the median edges of the head capsule behind the gular plate "gu" in the trichopterous larva shown in Fig. 24 (in which there is a midgular suture "mgs" like that of the beetle larva shown in Fig. 27) would lend weight to the view that the midgular suture "mgs" is formed by the approximation of the ventro-median edges of the head capsule along the median line of the head. On the other hand, the midgular suture "mgs" of Figs. 24 and 27, may have been formed secondarily in the integument of the head capsule as the result of the formation of a midventral implex or infolding of the body wall, such as frequently occurs along the midventral line of the thoracic region. Comstock and Kochi, 1902, suggest that the midventral suture of the thoracic segments "perhaps represents the neural groove of the embryo;" but I am inclined to attribute another origin to the suture in question—which probably arose through the formation of an infolding of the body wall for muscle attachment.

A study of the condition found in the different castes of termites throws some light upon the rather difficult question of the origin of the gular region, since in the termites, at least, the gular region appears to represent the posterior portion of an originally distinct plate which has become adherent to the head capsule. Thus, for example, in the head of a winged termite such as that shown in Fig. 13, the gular region "gu" forms the posterior portion of a distinct *gularmental plate* bearing the labels "gu" and "sm." In the soldier caste of this same termite, on the other hand, the posterior portion of the gularmental sclerite (bearing the labels "sm" and "gu" in Fig. 16) becomes "soldered onto" the head capsule to form the gular region, "gu," while the anterior portion of the gularmental area, bearing the label "sm," remains free and forms the submental region. We may therefore conclude that in some cases at least, the gularmental plate ("gu" and "sm" of Fig. 13) becomes elongate and its posterior portion is more or less closely fused with the head capsule to form the gular region "gu" of Fig. 16. In such instances, the lateral margins of the plate in question may be represented by the *gular sutures* on either side of the gular region "gu" shown in Fig. 16.

The *labium* or under lip is formed by the union of a pair of mouthpart-limbs (second maxillæ) similar to the maxillary mouthparts. The statement so often made that the neck plates, or cervical sclerites, represent the labial segment whose appendages have left the neck region and have migrated into the head region to form the labium, is wholly false, and is unsupported by a single bit of anatomical or embryological evidence. This matter, however, has been fully discussed in an article by Crampton, 1917, and need not be further considered here.

The pleural region of the labial segment is included in the region about the occipital foramen referred to as the "trophi-ger" or trophi-bearing area, and forms the narrow marginal area shown in Figs. 13, 10, etc. It sometimes bears an *occipital condyle* or process, with which the anterior process of the lateral neck plate articulates to aid in supporting the head capsule, while allowing for the freedom of movement of the head.

Holmgren, 1909, states that "an embryological study (of the second maxillæ or labial appendages) further indicates that the submentum is formed by a portion of the articulatory membrane between the second maxillary segment (or labial segment) and the first thoracic segment, and therefore has nothing to do with the second maxillæ (labial appendages)." Holmgren, Heymons, and other embryologists likewise agree that the hypopharynx or "tongue" is formed in part by the sternum of the labial segment, and Boerner, 1903, states that he considers it quite impossible to regard the mentum, submentum and gula as the sternites of the labial segment, "since in some insects, traces of a true (labial) sternum are retained between the bases of the coxæ of the posterior mouthpart-limbs." In other words, Boerner regards the median triangular area between the bases of the structures labeled "pgr" in Fig. 10, as the representative of the sternum of the labial segment. Whether these views are correct or not, I cannot say, although I have a strong feeling that either the mentum, or a portion of the submentum may be formed from the sternal area of the labial segment (in addition to the basal portion of the hypopharynx which is formed from the sternal area of the labial segment). What proof there is to be drawn from embryology, however, would not bear cut the latter view—at least so far as is at present known; and under these conditions, it would be wholly unjustifiable to claim that the mentum, or a part of the submentum are formed from a portion of the sternal region of the labial segment. On this account, I have provisionally accepted the view that the submentum and mentum are secondarily formed sclerites situated behind the true labium, in the following discussion. It has been found convenient, however, to treat the underlip as though it were composed of three principal plates or areas, in comparing this region in the different types of insects; and for the sake of convenience, I have referred to these three plates or areas as the *gula-mentum* (i. e., the region bearing the labels "gu" and "sm" in Fig. 23), the *mentum*, labeled "mn" in Fig. 23, and the true labium, or *eulabium*, which bears the labels "prm," "lg" and "lp," in Fig. 23.

The *gula-mentum* ("gu" and "sm" of Figs. 23, 13, etc.) becomes divided into a gular region and a submental region in some insects, while the gular portion becomes "soldered" onto the head capsule in some insects (e. g., "gu" of Fig. 16) as was stated above; and the gular region may be further augmented by the addition of portions of the integument behind the gula-mentum. The gular region "gu" is separated from the *submentum* "sm" by a *pregular cleft*, or *suture*, in such insects as the caddice fly larva shown in Fig. 24, and the occurrence of such a pregular suture is of value in marking off the posterior extent of

the submentum. The suture in question, however, is rarely present in insects in general, and in such cases the posterior limits of the submentum are demarked by an imaginary line drawn across from one gular pit "gp" of Fig. 15, to the other gular pit, or by a line drawn across from the base of one maxillary cardo "car" of Fig. 12, to the other, and corresponding in general to the line behind the label "sm" in Fig. 12. Dr. Craighead informs me that the submento-mental muscles labeled "11" in Figs. 11 and 14, which extend from the posterior border of the submental region to the posterior portion of the mental region, serve to demark the submental region "sm," internally; and since the posterior line of attachment of these muscles corresponds in a general way to the posterior border of the submentum, they offer a valuable means of determining the homologues of the submental region when it is not clearly demarked externally. The most reliable method of determining the posterior limits of the submentum on the external surface of the head, however, is to draw an imaginary line between the bases of the cardines "car" of Figs. 24, 21, 20, 26, 31, 22, 9, 8, 7, etc., since it is not always possible to dissect a specimen (e. g., as is the case with dried material) in order to determine the origin and insertion of the muscles in question.

In the insects shown in Figs. 21, 22, etc., the submental region contains two small plates, the *submentales*, "sml," situated at the base of the maxillary cardines "car." These submentals do not comprise the entire submental region, and in some insects, such as the one shown in Fig. 20, the submentals are represented by the small areas labeled "sml" alone. In the lepidopterous larva shown in Fig. 25, the areas labeled "sml" occupy a position at the bases of the maxillary cardines, "car," as do the submentals of the insects referred to above; and the areas labeled "sml" in Fig. 25, as well as the ill-defined areas bearing the label "sml" in Fig. 29, may therefore be interpreted as representing the submentals of other insects. In the caterpillar shown in Fig. 28, the submentals "sml" are rather heavily chitinized and pigmented, and might be mistaken for the maxillary cardines, but the true cardo of the maxilla is the plate labeled "car" in Fig. 28. The submental region is membranous in some insects, such as those depicted in Figs. 31, 77, etc., while in such insects as the beetle, shown in Fig. 17, "sm," it is strongly chitinized and is deeply emarginate anteriorly.

In the Neuropteran *Nemoptera* (Fig. 86) and in the Mecopteron *Bittacus* (Fig. 85) the principal part of the submentum "sm" forms a portion of the slender column-like sclerite whose anterior region "mn" has been homologized with the mentum; and this tendency toward the formation of a column-like sclerite in the mental region is also found in some Diptera. Whether the submentum includes the entire plate bearing the label "sm" in Figs. 10 and 6, or not, I cannot say; but it is very probable that the plate in question contains the gular region as well. It is also possible that the anterior, paler area bearing the label "sm" in Fig. 6, represents an anterior division of the submentum.

The *mentum*, "mn" of Figs. 5, 6, 7, 8, 9, 10, 23, 31, 12, 15, 77, etc., is the region between the submentum, "sm," and the eulabium, or true

labial region bearing the labels "pgr," "ls," "prm," etc., in the figures in question. The mentum "mn" forms the second of the plates forming a series of three in the underlip region of the Neuropteran shown in Fig. 23, which I have taken as the basis for comparison with the higher insects. The mentum, "mn," may be fused with the region "sm" behind it, as in the insects shown in Figs. 85, 86, etc.; it may be separated from the submental region "sm" by a clearly defined *mental suture* as in Figs. 23, 26, 7, etc.; it may be demarked merely by a faint dividing line between it and the submental region as in Fig. 13, etc.; or it may be a distinct plate "mn" as in the insects shown in Figs. 82, 77, 15, 6, etc. In the insects depicted in Figs. 21, 31, 17, etc., the mentum is represented by a membranous area bearing the label "mn." The *mentales* or small sclerites bearing a seta and situated in the posterior region of the mentum, "mn" of the caterpillar shown in Fig. 31, or in the trichopterous larvæ shown in Figs. 21, 20, etc., are possibly homologous with the chitinized areas in the posterior region of the mentum "mn" of the Neuropteran larva shown in Fig. 12.

The *eulabium* comprises the distalmost, or anteriormost portion of the underlip region beyond the mentum, "mn," from which it is separated by a *eulabial suture* in the insects shown in Figs. 23, 20, 27, 13, 15, 17, etc. The eulabium, as was stated above, is the true labium, formed by the union of the second maxillæ. I would emphasize the fact that the labial appendages are homologous with the second maxillæ of the Crustacea (see articles in bibliography) and it is wholly incorrect to maintain that the so-called superlinguæ on either side of the hypopharynx of insects are homologous with the first maxillæ (i. e., the maxillulæ) of Crustacea as is done by practically all recent investigators, since the "superlinguæ" are homologous with the *paragnaths* of Crustacea, and the labial appendages represent the true second maxillæ of Crustacea, as has been brought out in a paper published in the 50th. Annual Report of the Ent. Soc. of Ontario, in a preliminary note in the Transactions of the Ent. Soc. of London, and in a more lengthy paper on this subject, illustrated by drawings of the parts in question in Crustacea and insects, which will soon be published in Psyche, and the Proc. Ent. Soc. Washington for 1921.

As was mentioned in the preceding discussion, the greater portion of the sternum of the labial segment enters into the composition of the *hypopharynx*, or tongue-like structure on the floor of the mouth cavity. It is very probable, however, that the *labiosternite* or median triangular area between the bases of the structures labeled "pgr" in Fig. 10, represents a portion of the sternal region of the labial segment. The *palpifers*, "pgr," or palpi-bearing structures on either side of the median triangular area shown in Fig. 10 (also structures labeled "pgr" in Figs. 6, 7, 15, 81, etc.) together with the labiostipes, "ls," represent portions of the basal segments of the modified limbs forming the labium, while the distal segments of these limbs (representing the terminal segments of the "endopodite" of a crustacean limb) form the *labial palpi* "lp" of Figs. 6, 7, 10, 15, etc. Outgrowths of the basal segments "pgr" and "ls" of the limbs (these outgrowths possibly represent endites or "gnath-

obases" of a crustacean limb) form the *glossa*, "gl," and *paraglossa*, "pg," of the labium (see Figs. 6, 10, etc.) The glossæ, "gl," of Fig. 13, 10, etc., are sometimes referred to as the inner lobes of the labium, while the paraglossæ "pg" are sometimes referred to as the outer lobes of the labium. The sclerite labeled "ls" in Figs. 10, 6, 13, etc., is sometimes called the "stipes," but since the term stipes is restricted to a sclerite of the maxilla, I would refer to the sclerite "ls" as the *labio-stipes*, to indicate that it is a labial structure. The labiostipes "ls" bears the inner and outer lobes of the labium (i. e., "gl" and "pg" of Figs. 6, 10, etc.) in some insects.

Various modifications of the above-mentioned structures are met with in different insects. Thus in the beetle larva shown in Fig. 8, a *ligula*, labeled "lg" occurs in the region originally occupied by the inner and outer lobes ("gl" and "pg" of Figs. 10, 6, etc.), and it is quite probable that the ligula "lg" of the beetle larva shown in Fig. 8, (or the insects depicted in Figs. 9, 49, 23, 27, etc.) represents the fusion product of the two inner lobes (glossæ) of the labium, with which the outer lobes (paraglossæ) may also have united. In the insects shown in Figs. 17 and 15, on the other hand, the ligula "lg" is apparently formed by the united glossæ only, since the paraglossæ "pg" are apparently still distinguishable. In most instances, however, the general term ligula has been applied to the unpaired median terminal structure projecting between the labial palpi (i. e., "lg" of Figs. 8, 9, 27, 23, etc.) regardless of whether it is formed by the united glossæ alone, or whether the paraglossæ have also entered into its composition.

In the larvæ shown in Figs. 8, 20, 25, 31, 49, etc., there occurs a *basilabium*, "prm," or basal labial plate formed by the union of the labial stipes "ls" of Figs. 6, 10, etc. This basal labial plate may also include the palpigers in its composition, and is typically a transverse chitinization of the area at the base of the labial palpi. In some insects it is not demarked from the ligula "lg" (as in Figs. 23, 9, etc.) while in others, such as those depicted in Figs. 8, 22, etc., it is demarked by a faint line, or is differentiated by a stronger chitinization and pigmentation.

In connection with the discussion of the terminal region of the labium, the *spinneret* "spt" of Figs. 25, 31, etc., should be mentioned. This spinneret is usually closely associated with the ligular region, although a portion of the hypopharynx may possibly be involved in the spinning structure. Whether or no the structure labeled "spt?" in Fig. 30, is homologous with the spinneret of lepidopterous larvæ, is a question which I have been unable to decide, and I have therefore merely offered the suggestion as a possibility, rather than as a definite opinion in the matter. A comparative study of this region in the Trichoptera, Lepidoptera, and other spinning larvæ is greatly needed, and would be of considerable value in the matter of determining the affinities of the insects having caterpillar-like larvæ.

It is very unfortunate that Peterson, 1916, who follows Kellogg, 1899-1902, in his interpretation of the parts, did not study the mouth-parts of the Neuroptera such as *Nemoptera* (Fig. 86) and the Mecoptera,

such as *Bittacus* (Fig. 85), *Panorpa* (Fig. 82), etc., before attempting to homologize the parts in the highly specialized order Diptera, instead of attempting to compare the Diptera directly with the lower orders such as the Orthoptera, etc., since the Neuroptera and Mecoptera mentioned above furnish the key to the interpretation of the parts in the Diptera, and the evidence they offer is most convincing. Wesche, however, is probably responsible more than anyone else for the confusion of the interpretation of the parts of the trophi by recent Dipterists, and Peterson's work is a great improvement over that of Wesche, Smith and others who have misinterpreted the structure of the mouthparts in a most amazing fashion, due to the fact that they have ignored the intermediate forms between the lower orders and the higher ones in attempting to homologize the parts in Diptera.

As I pointed out in a recent paper (Crampton, 1917) dealing with the head region of Neuroptera, Mecoptera, Diptera, etc., the labial palpi, "lp," of the Neuroptera such as *Nemoptera* (Fig. 86) tend to become approximated in the median line of the head (compare Fig. 86 with the Neuropteran shown in Fig. 81) while the ligula "lg" tends to disappear. A further step is represented by the Mecopterid shown in Fig. 85, in which the ligula "lg" of Fig. 86 has completely disappeared, although the labial palpi, "lp," have retained their typical three-segmented condition, and the palpigers, "pgr," are still partially distinct. In the Mecopterid shown in Fig. 82, the labial palpi, "lp," have been reduced to two segments, the basal one being quite thick and "fleshy," while the terminal one is small and slender. The sclerites which I have interpreted as the palpigers, "pgr," (although they may possibly represent the basal segments of the labial palpi instead) tend to unite, and the mentum "mn" is a broad plate somewhat produced anteriorly. A further modification is shown in the Mecopterid depicted in Fig. 84, the labial palpi being reduced to the fleshy lobes, "lp," while the palpigers have united to form the region "pgr," which is but indistinctly demarked from the mentum "mn" behind it. The labial palpi, "lp," have even developed "pseudotracheæ" like those occurring on the labial lobes of certain Diptera, in some of the Mecoptera; and the whole trend of development in the Mecoptera indicates the origin of the inherent tendencies which find opportunity for fuller expression in the Diptera. Thus in the Dipterid shown in Fig. 83, the labial palpi "lp" are fleshy lobes like those of certain Mecoptera,* and they have even retained traces of two segments in the Dipterid shown in Fig. 83, which in this respect is more primitive than the Mecopterid shown in Fig. 84. The palpigers, "pgr," of Fig. 83 are also distinct, although they have completely united in the insect shown in Fig. 84, to form the region labeled "pgr." The narrow median structure labeled "mn" in Fig. 83, is clearly the mentum. When one compares the Diptera with the

* Dr. Tillyard, to whom I have shown the accompanying figures, in discussing the interpretation of the mouthparts of the Diptera, informs me that he has come to the same conclusion, independently, in comparing the head structures of Diptera with those of the Mecoptera, thus giving additional weight to the correctness of the interpretation here offered.

Mecoptera and with the Neuropteran shown in Fig. 86, it is thus a very simple matter to determine the interpretation of the parts of the labium of the Diptera, and if Peterson and Wesche had only used these forms instead of trying to compare the Diptera directly with the Orthoptera, etc., they would have had no difficulty in determining the homologies of the Dipteran structures, so far as the principal features of the mouthparts are concerned. I must admit, however, that the interpretation of the slender lobes between the terminal segments of the labial palpi labeled "lp" in Fig. 83, has given some trouble. They may possibly represent the paraglossæ ("pg" of Fig. 77), for example) of other insects, although I am more inclined to regard them as merely lobe-like outgrowths of the segments of the palpi.

The interpretation of the parts of the labium of the hemipterous insects has proven to be a rather difficult problem, largely due to the fact that I have not as yet been able to make a thorough study of the mouthparts of the Psocidæ (which are closely related to the hemipterous insects) due to lack of proper material. From what is known of the tendencies for the parts to unite in the Mecoptera discussed above, however, I think we are justified in assuming that the sclerites labeled "lp" in Fig. 75 (of a species of *Cicada*) represent the more or less closely united labial palpi, while the structures labeled "pgr" in Fig. 75, very probably represent the palpigers "pgr" of Figs. 82, 86, 83, etc., and the plate "mn" of Fig. 75 is therefore largely composed of the mentum; the other basal structures of the underlip region are probably included in the more membranous region behind the mentum "mn." When we turn to the true Hemiptera (Heteroptera), however, the parts have become so modified that it is very difficult to determine their homologies in many instances. Dr. Parshley has called my attention to the fact that hemipterists frequently interpret the structures labeled "ap" in Fig. 76, as the "labial palpi" in the belostomatids; but Heymons does not consider that the structures in question are the true labial palpi, from his embryological studies. I am more inclined to regard the appendages "ap" of Fig. 76, as lateral lobes of the region "pgr," which have become demarked by the formation of a secondary suture; and the appendages "ap" therefore have nothing to do with the true labial palpi, which probably enter into the composition of the sclerite labeled "lp?" in Fig. 76. The structures labeled "pgr" and "mn" in Fig. 76, are possibly the palpigers and mentum, "pgr" and "mn," of the *Cicada* shown in Fig. 75.

I would call attention to the fact that in all of the coleopterous larvæ which I have examined, the labial palpi, when well developed, are made up of not more than *two segments*, while in all of the neuropterous larvæ which might be mistaken for coleopterous larvæ have at least *three segments* in the labial palpi. This distinction may be of value in distinguishing between the two types of larvæ, since it is very difficult to find any characters for differentiating between the two groups of insects, and any distinguishing feature which "holds good" in the majority of cases, should be of considerable interest on this account.

The Dermapteron shown in Fig. 7 is a primitive, but highly aberrant earwig, and the condition occurring in its mouthparts may therefore not be as typical as though another form had been chosen to illustrate the group. In all of the Dermaptera which I have examined, however, the paraglossæ "pg" (Fig. 7) are long and slender, and the glossæ have apparently been lost, so that these features, in conjunction with the peculiar character of the gula "gu" (which is a narrow transverse sclerite in the earwigs) may be of value in characterizing the order Dermaptera.

In the larvæ of the Neuroptera related to the Myrmeleonidæ (Figs. 44 and 47) there is a tendency for the gula, "gu," submentum, "sm," and mentum, "mn," to unite, while the antero-lateral structures labeled "pgr" bearing the labial palpi, "lp," acquire a greater mobility to compensate for the loss of movement on the part of the rest of the labial structures. The structure labeled "pgr" in Figs 44 and 47 may not be the exact homologues of the palpigers "pgr" of other insects; since other portions of the labium probably enter into their composition; but the term palpiger as applied to the structure in question is sufficiently accurate for practical purposes. In the neuropterous larva shown in Fig. 46, the labial palpi are apparently composed of more than the usual three segments found in the palpi of most Orthoptera, etc., and it is quite probable that a secondary segmentation of the palpi has taken place in the Neuropteran in question. Faint indications of such a secondary segmentation of the labial palpi, "lp" are to be found in the larva shown in Fig. 51, in which the labial palpi are either composed of but three actual segments, with a distinct palpiger having the appearance of a fourth segment, or a fourth segment has been formed in an originally three segmented labial palpus. The fact that the palpi are but three-segmented in the primitive neuropterous larvæ shown in Figs. 23, 12, 15, etc., would indicate that three is the original number of the labial segments of the group as a whole. In connection with the discussion of the labial palpi of the Neuroptera, I would call attention to the *palpimaculæ*, "pm," or sense organs borne on labial palps of the Myrmeleonid shown in Fig. 70. A similar sense organ occurs on the labial palp of *Nymphes* (Fig. 72, "pm") and this fact adds weight to the view that the Myrmeleonidæ and *Nymphes* are quite closely related.

The *maxillæ* of an insect are homologous with the first maxillæ (not the second maxillæ, as Folsom and others maintain) of Crustacea, as may be seen by comparing an embryo of any primitive insect, with the embryo of a crustacean, such as the isopodan *Jaera*, figured by Mc-Murich. The sternal region of the maxillary segment takes part in the formation of the hypopharynx, or tongue-like structure on the floor of the pharyngeal cavity, while the pleural region of the maxillary segment enters into the composition of the posterior region of the head, called the "trophiiger," which is situated near the occipital foramen, or posterior opening through which the nerve cord, gullet, etc., pass into the head capsule. The pleural region of the maxillary segment is demarked from the pleural region of the labial segment behind it by

the posterior tentorial invaginations, according to Riley, 1904, in the embryo of the cockroach.

The membrane at the base of the maxilla, labeled "bm" in Fig. 5, etc., may be termed the *basimaxillary membrane*. A plate called the *basimaxilla*, "bm," of Figs. 8, 9, etc., results from the chitinization and pigmentation of the membranous region at the base of the maxilla in certain coleopterous larvæ, etc. This basimaxillary plate, "bm," of Figs. 8 and 9, should not be confused with the subdivision of the cardo labeled "pac" in Figs. 5, 6, etc., since the latter sclerite, "pac," is a demarked subdivision of the cardo, and therefore does not arise through a greater deposition of chitin and pigment in the membrane at the base of the maxilla, as is the case with the basimaxillary plate.

As was pointed out in a paper dealing with the maxillæ of orthopteroid insects (Crampton, 1916) the basal sclerite or *cardo* of the maxilla of the insect shown in Fig. 10, for example, is divided into a *eucardo*, "euc," and a *paracardo*, "pac," while the *stipes*, or second segment of the maxilla, is divided into a *eustipes*, "cus," and a *parastipes*, "pas." The parastipes, "pas," however, is apparently a distinct narrow sclerite formed along the mesal margin of the stipes, and it is doubtful that it arose as a demarked portion of the stipes proper. In fact, it would appear from a comparison with the structures of certain Crustacea, that the parastipes, "pas," originally was a part of the basal segment or cardo, and become secondarily united with the stipes, but it is simpler to treat of the parastipes as a portion of the stipes.

In a paper which will be published in the 1921 volume of the Proceedings of the Ent. Society of Washington, it has been pointed out that the maxilla of a larval neuropteroid such as the one shown in Fig. 23, corresponds in a remarkable fashion to the typical crustacean limb represented by the maxilliped of *Gammarus* (an amphipodan crustacean) for example, since in both cases, the mouthpart-limb is composed of seven segments, and the correspondence in the relative sizes of the individual segments, and the processes they bear, is marvellously close, when one takes into consideration the fact that we are dealing with forms belonging to distinct classes of arthropods. Such a comparison of the parts in insects and Crustacea very clearly demonstrates that the basal segment or cardo, "car," of Fig. 23 represents the basal segment, or coxopodite, of a crustacean limb. The second segment, or stipes, "bs," of Fig. 23, which bears a median process, "la," (the lacinia) in the insect there figured, clearly corresponds to the second segment or basipodite which also bears a median process or endite in a crustacean mouthpart-limb. The third segment, or palpifer, "ds," of Fig. 23, which bears a median process, "ga," (the galea), evidently corresponds to the third segment or ischiopodite, which also bears a median process or endite in the crustacean mouthpart-limb. The four segments of the maxillary palpus, "mp," of Fig. 23, correspond (even to the relative lengths of the component segment) very closely to the four segments of the endopodite of the maxilliped of *Gammarus*, and there can be no doubt that the maxillary palpus of an insect's maxillary appendage corresponds to the endopodite of a crustacean limb, while the palpifer

with its endite (the galca) and the stipes, with its endite (the lacinia) correspond to the third and second segments of a crustacean mouthpart limb (which also bear endites in *Gammarus*' maxilliped), and the cardo corresponds to the basal segment of such a crustacean mouthpart-limb.

A *basistipes*, "pst," is demarked in the basal region of the stipes, "sti," of the Dermapteron shown in Fig. 7, and if one compares the entire stipes region, bearing the labels "cus" and "pas" in Fig. 10, of a blattid, with the region labeled "pst" in Fig. 7, it should be clear to anyone that the small basal area, "pst," of Fig. 7 is not the entire stipital region "cus" and "pas" of Fig. 10,—which may be taken as the basis for comparison with the higher forms. Similarly, when one compares the maxilla of a primitive Coleopteron, such as that shown in Fig. 4, with the maxilla of the Dermapteron (carwig) shown in Fig. 7, it should be perfectly evident that the latero-basal area, "pst" of the stipes of the beetles maxilla (Fig. 4) is in every way homologous with the latero-basal area, "pst," of the stipes of the carwig's maxilla (Fig. 7). On this account, it is quite incorrect to term the area "pst" the "stipes" in beetles (Figs. 4, 3, etc.), as is done by coleopterists in general. In fact, if one compares the maxilla of the beetles shown in Figs 4, etc., with that of the beetle shown in Fig. 1, in which the stipes, "sti," is retained in a condition more nearly approaching that typical of the lower insects, it is at once apparent that the small area, "pst," of the beetle shown in Fig. 4 cannot possibly be homologized with the entire area, "sti," of the beetle shown in Fig. 1, and since the area "pst" of Fig. 4 evidently represents a basal subdivision of the entire stipes, it has been referred to as the *basistipes* in the present paper. A *basistipes*, "pst," is demarked from the stipital region only in certain Coleoptera (Fig. 4) and Dermaptera (Fig. 7) so far as I am aware, and the presence of this peculiar subdivision of the stipes in the Coleoptera and Dermaptera alone, would add further support to the view that the Coleoptera are extremely closely related to the Dermaptera—which is borne out by the study of numerous other structural details as well.

In the Dermapteron shown in Fig. 7, the *palpifer*, "pfr," is clearly demarked from the stipes, but the palpifer is not closely associated with the galea, "dg," in this insect, as is the case with the larva shown in Fig. 23. On the other hand, if one compares the larval Neuropteran shown in Fig. 23, with the larval Coleopteron shown in Fig. 27, it will be noted that the palparium or palpifer, "ds," which bears the galea, "ga," is slender, and resembles a basal segment of the palpus in both of these insects, thus adding further support to the view that the Coleoptera are very closely related to the Neuroptera (as well as to the Dermaptera). The Coleoptera are anatomically intermediate between the Dermaptera on the one side and the Neuroptera on the other, and, strange to say, an adult Coleopteron is, as a rule, more like a Dermapteron in structure than it is like a Neuropteran, while a larval Coleopteron is usually more like a larval Neuropteran in structure (although in some features larval Coleoptera are very like immature Dermaptera also).

In the Neuropteran shown in Fig. 86, the palpifer is adherent to the stipes, while in the Mecopterone shown in Fig. 85, it is less closely associated with the stipes, and in the Mecopterone shown in Fig. 84 it has the appearance of a basal segment of the maxillary palpus, "mp." I am not sure of this interpretation, however, since the structure interpreted as the palpifer may actually be a basal segment of the palpus, and on this account no label was affixed to the structure in question. In the beetle shown in Fig. 3, the palpifer, "pfr," is much larger than in most Coleoptera (Figs. 1, 3, etc.); it has also developed a peculiar prominent *palpiferal angle* or projecting angle-like process in the region bearing the label "pfr," and through a distortion or shifting of the parts, the maxillary palpus, "mp," comes to lie over the surface of the palpifer in a peculiar fashion.

I had at first considered that the areas labeled "bs," "in" and "ds" in Fig. 25, for example, represent three divisions of the stipes (i. e., basistipes, interstipes and dististipes) and therefore affixed to these areas labels indicating that they are divisions of the stipes. After the blocks for the plates had been made, however, and it was therefore too late to change the labelling, a further study of the palpiferal region brought to light considerable evidence for considering that the sclerite labeled "ds" in Fig. 25 represents the true palpifer or palparium, and is therefore not a part of the stipes. The area bearing the label "bs" in Fig. 25, however, is apparently a *proxistipes*, or proximal subdivision of the stipes, and the area labeled "in" is apparently a *dististipes*, or distal subdivision of the stipes. In Figs. 31, 23, 27, 22, 21, 20, 24 and 26, on the other hand, the sclerite labeled "bs" apparently represents the entire stipes, rather than a proximal subdivision of the stipes, as the label indicates, while the sclerite labeled "ds" in these figures apparently represents the true palpifer instead of a distal subdivision of the stipes, as the labels indicate. It thus comes about that the label "bs" indicates a basal subdivision of the stipes in Figs. 25, etc., but in the other figures mentioned above, the label "bs" indicates the entire stipes, but I have been unable to change the labeling in the plates to indicate this fact.

In the sawfly larvæ shown in Fig. 49 and 54, a narrow marginal region bearing the label "gg," bearing the galea "ga" is demarked by a well defined suture. The area labeled "gg" in these figures may represent the palpifer, since it bears the galea—as is true of the palpifer in Fig. 23, etc. If this be correct, the sclerite labeled "pfr" in Figs. 49 and 54, is merely a modified basal segment if the maxillary palpus, "mp," instead of representing the palpifer as indicated by the label. Provisionally, however, I have followed the customary usage of hymenopterists in referring to the sclerite labeled "pfr" in Figs. 49 and 54, as the "palpifer." In the sawfly larva shown in Fig. 30, the so-called palpifer, "pfr," curves outward and forward to form the peculiar *palpiferal process*, while the stipes extends laterally in the *stipital angle* or *process*, bearing the label "sa." There is also a small *cardine angle*, "ca," in the sawfly shown in Fig. 30; and the peculiar processes

and angles formed by the parts of the maxillæ in the sawfly larvæ may offer points of value in their classification.

The *galea* is divided into a basal segment, or *basigalea*, "bg," and a distal segment, or *distigalea*, "dg," in the sawfly larvæ shown in Figs. 54 and 49, as is also the case with the *galea* "ga" of the larvæ shown in Figs. 20, 22, etc. These segments of the *galea* are apparently homologous with the two segments of the *galea*, "ga," of the beetle shown in Fig. 3, and with the structures labeled "bg" and "dg" in lower insects (Figs. 10 and 7). These parts of the *galea* were designated as the *basigalea* and *distigalea* in a paper dealing with the maxillæ of Orthoptera (Crampton, 1916); but Yuasa, 1920, in his paper on the mouthparts of the Orthoptera has substituted a terminology of his own for the parts in question. Since the designations originally applied to the parts are as suitable as those which Yuasa has attempted to substitute for them, the original terminology has been retained in the present paper.

Since the *galea*, "ga," of the larva of *Corydalid* (Figs. 15 and 14) is not like that of the adult ("ga" of Fig. 11) in appearance, and since the *lacinia*, "la," of an adult *Corydalid* (Fig. 11) cannot be readily detected in the larval stages (Fig. 15), there might be some doubt as to the interpretation of the parts in the larva and adult. I have therefore included Dr. Craighead's figures of the musculature of an adult and larval *Corydalid* (Figs. 11 and 14) in order to show that practically the same muscles occur in both stages (so far as the type of muscle is concerned) and furnish an excellent means of determining the homologies of the parts. As is shown in Dr. Craighead's figures, the tentorio-cardine muscles labeled "3" and "4" in Figs. 11 and 14 extend from the tentorium to the *cardo* in both adult and larval stages of *Corydalid*, and the same paragula-cardine muscles bearing the label "5" extend from the paragular region to the *cardo* in both larval and adult head. Dr. Craighead states that "the *cardo* always articulates to the hypostoma and carries at least two muscles, one (number 3) attaching it to the tentorium, and the other (number 5) attaching it to the epicranium."

The tentorio-stipital muscle labeled "2" and the paragula-stipital muscle labeled "6" connect the tentorium and paragular region with the base of the *stipes* in both stages. With regard to the muscles to the *galea* and maxillary palpus, Dr. Craighead states that "the upper limit of the *stipes*, or more correctly, the insertion of its appendages, the *galea* and *lacinia*, is indicated by muscles "7" and "8," one attached to the base of the *galea*, the other to the basal joint of the palpi or palpifer and extending to the base of the *stipes*, or occasionally one may go to the *cardo* or a part of it may extend down further to the tentorium." It is quite apparent that muscles "7" and "8" are the same in both adult (Fig. 11) and larva (Fig. 14) of *Corydalid*, so that the structure labeled "ga" in Fig. 14 must be the homologue of the *galea* "ga" (Fig. 11) of the adult insect, since the same stipito-galeal muscle "7" is attached to the structure labeled "ga" in both larva and adult. The *lacinia*, "la," of the adult (Fig. 11) is apparently wanting in the larva (Fig. 14) of *Corydalid*, and Dr. Craighead states that "it (the *lacinia*) is considered to be lacking in most coleopterous larvæ. However, in

certain larvæ two lobes appear, and, as far as I know, only one carries muscles." (The lacinia, "la," of Fig. 11 is thought by Dr. Craighead to carry no muscles, thus resembling the inner lobe of the maxilla of the larval Coleoptera, in this respect). He also states that "in certain forms there are indications pointing toward a maxilla with only lacinia or only galea present." In this connection, it may be remarked that the tentorio-labiostipital and tentorio-palpiger muscles labeled "9" and "10" in Figs 11 and 14, as well as the submento-mental muscles labeled "11" in these figures are the same in adult and larva of *Corydalidæ*, so that all of the important parts of the trophi (with the exception of the maxillary lacinia) of an adult *Corydalidæ* are represented in its larva.

Although there is a slight difference between the mouthparts of an adult and larval *Corydalidæ*, as was mentioned above, the mouthparts are essentially the same in both larva and adult of the lower Neuroptera (*Corydalidæ*, *Sialis*, *Raphidia*, etc.), the resemblance between the mouthparts of the two stages being very marked in *Raphidia* (a larva of which is shown in Fig. 12), thus indicating a much feeble tendency toward complete metamorphosis in lower Neuroptera. When we turn to the larvæ of the higher Neuroptera, however, we find a much stronger tendency toward complete metamorphosis, and the mouthparts for the most part have become so greatly modified in adaptation to the "larval" methods of getting food, etc., (most of these larvæ suck the blood of their prey) that it is very difficult to determine the interpretation of the terminal portions of the maxillæ, and until suitable material for dissecting the muscles has been obtained, the interpretation of the homologies of the terminal portions of the maxillæ is largely a matter of guesswork. Dr. Tillyard has suggested to me that the slender terminal portion of the maxilla bearing the label "mx" in the neuropterous larvæ shown in Figs. 46, 44, 51, etc., may represent the lacinia labeled "la" in Fig. 23 of the larva of *Sialis*, and there is much to be said in favor of this view. On the other hand, the structure in question may not represent the lacinia "la" of Fig. 23, but may rather be homologous with the galea-bearing (or palp bearing) structure labeled "ds" in Fig. 23, with which the galea (or the palp) has fused, and the interpretation of the structures in question can be definitely determined only when material suitable for study has been obtained for an examination of the musculature—although the remarkable larvæ of *Ithone* recently discovered by Dr. Tillyard may throw some light upon this subject.

The *mandible* of an insect represents a single basal segment of a trilobite limb, as can be seen by tracing the development of the mandibular appendage through a series represented by the trilobite *Triarthrus*, the Crustacea *Nebalia*, *Mysis*, *Apsuodes*, etc., and the insect *Machilis*—as has been done in a paper soon to be published in the Journal of the N. Y. Ent. Soc., 1921. When one studies such a series, it becomes apparent that the gnathobase region of the basal segment of the trilobites limb becomes differentiated into a biting region and a grinding region as we pass through the series of Crustacea mentioned above, and the biting region become the *incisor region* bearing the "teeth" for cutting food, while the grinding region (which projects quite markedly in some

Crustacea) forms the so-called *mola* or *molar region* in insects, the molar or grinding region of certain coleopterous larvæ being a region of some interest in the classification of the larval forms. In the mandibles of Crustacea, a fringe of flattened seta-like hairs occurs below the incisor region, between the latter and the molar region of the mandible. Some of the flattened seta-like structures fuse to form a movable appendage called the "*lacinia mobilis*" by carcinologists, and some entomologists have thought that a similar "*lacinia mobilis*" in the mandibles of insects represents the lacinia of an insect's maxilla. The idea that the various parts of the maxilla are repeated in the mandible (proposed by Packard, Smith, and other entomologists), which has received a rather widespread acceptance, is wholly unfounded and misleading, since the mandible represents only one segment (the coxopodite) of a limb, while the body of the maxilla (i. e., the part at the base of the maxillary palpus) is formed of more than one segment of such a limb (i. e., the basipodite and ischiopodite) and the parts are not at all comparable in the mandible and maxilla, since they are formed in different ways in the two structures. Furthermore, the palpus of the mandibular limb is lost in many of the higher Crustacea, and a structure homologous with the mandibular palpus of the Crustacea has not been found in any insects, despite the statement to the contrary made by several persons who have not properly studied the evolution of the mandibular appendage in insects and related Crustacea.

With regard to the portions of the head capsule formed by the mandibular segment, there is a considerable difference of opinion on the part of embryologists in this matter. Thus Riley, 1904, states that a part of the postgena is formed by the pleural region of the mandible, while a portion of the hypopharynx is formed by the sternum of the mandibular segment. Holmgren, 1909, on the other hand, ascribes the "vertex" and genæ to the mandibular segment, in addition to the upper portion of the hypopharynx. It is difficult to believe that the genæ which are situated immediately above the mandibles and bear the mandibles in most insects, are not portions of the mandibular segment, rather than parts of the protocerebral segment to which Riley, 1904, assigns the genæ. I have, therefore, followed Holmgren in ascribing the genæ to the mandibular segment. As far as the *basimandibula* "bmd" of Fig. 39 is concerned, this sclerite is apparently formed by a chitinization of the articulating membrane at the base of the mandible and is not homologous with the trochantin or plate at the base of the leg in the thorax, as Comstock and others have maintained. Since the sclerite "bmd" of Fig. 39 is formed by the chitinization of the basimandibular membrane, or the articulatory membrane at the base of the mandible, it is also a part of the mandibular segment, as Riley, 1904, states, although it is strange that Riley did not also consider that the gena "ge" of Fig. 39, which is so closely associated with the region "bmd" is not also a portion of the mandibular segment.

The mandibles have two principal articulations with the head capsule. The dorsal articulation of the mandible occurs near the posterolateral angles of the clypeus, and the condyle of the mandible which

articulates with this region is called the *epicondyle*, or dorsal condyle of the mandible. A ventral condyle of the mandible called the *hypocondyle* articulates in an acetabulum or groove of the hypostomal region of the under side of the head. Comstock and Kochi, 1902, use the terms dorsal and ventral articulations of the mandible in the opposite sense from that employed here; but it is more logical to refer to an articulation which is on the dorsal surface of the head as the "dorsal articulation of the mandible," and the articulation which takes place on the ventral surface of the head as the "ventral articulation of the mandible," without reference to any supposed original position of the sclerites involved in these articulations.

The *hypopharynx*, in the broad sense of the term, includes not only the median tongue like organ or *lingua*, which projects from the floor of the mouth cavity, but also the *paragnaths* (called "superlinguæ" and "paraglossæ"), or lobe-like structures on either side of the median tongue, in such insects as *Hemimerus*, immature ephemerids, etc. Since the median tongue-like *lingua* is usually the only portion of the hypopharynx to be retained in certain insects, the term hypopharynx is usually applied to the *lingua* alone. The *lingua* is formed by the sternites of the labial, maxillary and mandibular segments, according to the embryological investigations of Heymons, Holmgren, and others; and a study of the Crustacea would indicate that this view is the correct one, since a ridge which is apparently the forerunner of the *lingua* of the hypopharynx of insects, is formed in the sternal region of the mouthpart segments of certain Crustacea.

The *paragnaths* ("superlinguæ") or lobe-like structures on either side of the median tongue or *lingua* of the hypopharynx of insects are clearly the homologues of the *paragnaths* of Crustacea, as may be seen by comparing the structures in question of an immature mayfly with the *paragnaths* of Crustacea such as *Asellus*, various Isopoda, Amphipoda, etc., (see article in Psyche, 1921) so that it is preferable to apply to these structures of insects the term applied to their homologues, the *paragnaths*, in Crustacea, instead of employing the term "superlinguæ" or the incorrectly applied term "paraglossæ" (which should be restricted to the labial structures of this name) for them. The *paragnaths* of Crustacea are apparently detached lobes of the first maxillæ which take up a position behind and slightly mesal to the bases of the mandibles in the higher forms; but in *Apus* and other primitive Crustacea, they are evidently lobes of the first maxillæ. It is wholly incorrect to homologize the *paragnaths* of insects with the first maxillæ (maxillulæ) of Crustacea, and to homologize the first maxillæ of insects with the second maxillæ of Crustacea, as is done by practically all recent investigators, since the *paragnaths* of insects are in every way homologous with those of Crustacea, and the first maxillæ of insects represent the first maxillæ (not the second maxillæ) of Crustacea, as has been shown in an article in the Transactions of the Entomological Society of London, 1921, and in an article which will shortly appear in the Proc. Ent. Soc. Washington, 1921.

The *tentorium* is apparently formed by three pairs of invaginations, two of which are anterior (a dorsal and ventral anterior pair of invaginations) forming the dorsal and ventral anterior arms of the tentorium, while the posterior ventral pair of invaginations form the posterior ventral arms of the tentorium. These tentorial arms, whose position is marked by the *frontal pits*, *gular pits*, etc., extend internally to the body of the tentorium. The ventral anterior arms of the tentorium may meet and unite to form a plate called the frontal plate of the tentorium by Comstock and Kochi, 1902.

Infoldings of the integument called *implexes* or *endoplicæ* are frequently formed in the different regions of an insect's body, for the attachment of muscles, or for the strengthening of the body wall somewhat after the manner of corrugations in sheets of metal. In the head capsule, however, these internal folds for the most part form ridges for muscle attachment. These have been described under the discussion of the regions of the head capsule in which they occur.

The foregoing description of the parts in insects in general, is offered merely as the basis for a further more detailed discussion of those external features of insect morphology which appear to be of value in determining the phylogeny and interrelationships of the various groups of insects (and their arthropodan relatives), and on this account the modifications occurring in many of the orders have not been treated of in the present paper, since these can be taken up more profitably in a detailed discussion of each group taken separately. The evidence bearing upon the question of the phylogeny or of the interrelationships of the different groups of insects which have been described in the present paper, may be briefly summarized as follows, leaving the more detailed comparison of the parts in the different orders to be discussed later.

RELATIONSHIPS INDICATED BY THE HEAD STRUCTURES.

A comparison of the head structures of the Diptera with those of the Mecoptera would indicate a very close relationship between these two orders. The fact that the labial palpi, "lp," assume the form of fleshy lobes at the end of the labium in the Mecopteron shown in Fig. 84, the fact that the lacinia of the maxilla is lost, and the galea, "ga," is reduced to a short slender structure, and the presence of the sense organ labeled "so" in the maxillary palpus of the scorpion fly shown in Fig. 84, all point to a close relationship to the Dipteron shown in Fig. 83, in which the same tendencies occur, and the sense organ, "so," occurs on exactly the same segment of the maxillary palpus as in the Mecopteron shown in Fig. 84. These facts are in full accord with the evidence of relationship between the Diptera and Mecoptera drawn from the study of the other regions of the body, such as the thoracic terga and wing bases, the genitalia and terminal abdominal structures, etc.

The Mecoptera may, therefore, be regarded as the nearest living representatives of the types ancestral to the Diptera, although it is by no means certain that both Diptera and Mecoptera were not derived from Neuroptera-like ancestors. In fact the latter is even more probable,

since the tendencies present in such Neuroptera as *Nemoptera* (e. g., the reduction of the hind wings to mere ribbon-like structures, suggesting the precursors of the halteres of Diptera, the elongation of the head region and the slender character of the mouthparts, which apparently presage similar tendencies occurring in the Diptera, the nature of the male genitalia, etc., which are somewhat like those of certain Diptera) are those which one finds recurring in many Diptera, and a number of these tendencies are also exhibited by certain Mecoptera. In fact, *Nemoptera* has more features suggestive of affinities with the Mecoptera and the Diptera than any other Neuropteran which I have been able to examine, and it serves as a connecting-link between the Neuroptera on the one side, and the Mecoptera, with the Diptera, on the other. *Nemoptera*, however, is a rather highly specialized Neuropteran, and, since the Mecoptera (and even the Diptera also) have retained certain features (genitalia, etc.) in a more primitive condition than *Nemoptera* has, the probabilities are that the Mecoptera (and Diptera) were derived from a common ancestral type which gave rise both to *Nemoptera* and to the Mecoptera, etc. Aside from the presence of the ligula, "lg," in *Nemoptera* (Fig. 86) the mouthparts of this insect are apparently even more like the mouthparts of the Mecopterite *Bittacus* (Fig. 85) than they are like the mouthparts of other Neuroptera, as one can see by comparing Fig. 86 of *Nemoptera* with Fig. 81 of a Neuropteran fairly closely related to *Nemoptera*, since the slender columnar structure bearing the labels "sm" and "mn" in Fig. 86 of *Nemoptera* bears a much stronger resemblance to the region bearing these labels in Fig. 85 of the Mecopterite *Bittacus*, than it does to the region bearing these labels in the Neuropteran shown in Fig. 81. Similarly the long slender maxillary galea, "ga," and the slender lacinia, "la," with its peculiar fringe in *Nemoptera* (Fig. 86) resemble the structures bearing the same labels in *Bittacus* (Fig. 85) much more closely than they do the structures bearing the same labels in the Neuropteran shown in Fig. 81. These and many other features of the body in general indicate a close relationship between *Nemoptera* and the Mecoptera (with the Diptera), and I am convinced that the immediate ancestors of the family to which *Nemoptera* belongs (i. e., the Nemopteridae) bore a very striking resemblance to the ancestors of the Mecoptera (with the Diptera). At any rate, we must admit that in order to properly interpret the homologies of the mouthparts, etc., of the Mecoptera and related forms, it is necessary to first study these structures in *Nemoptera*, so that there can be no possible objection to regarding *Nemoptera* as a form morphologically annectant between the rest of the Neuroptera and the Mecoptera (with their allies) even though *Nemoptera* itself may not stand in the direct line of descent of the Mecoptera and Diptera.

The Hymenoptera exhibit some very close resemblances to the Neuroptera in the nature of the mouthparts, and I am rather surprised that the points of similarity between the Coleoptera and Hymenoptera found in other structures, are not more evident in the mouthparts, although when more favorable material has been studied, other forms will doubtless be found which exhibit a greater resemblance between

the mouthparts of the two groups. The character of the structures bearing the label "pg" in Fig. 77 of a Hymenopteron is somewhat suggestive of the condition found in the Neuroptera (Fig. 81), and the tendency for the cardo, "car," of Fig. 77 to straighten out in line with the stipes, "sti," occurring in the Hymenoptera is also found in certain Neuroptera. On the other hand, the tendency to lose the lacinia, and the character of the galea, "ga," of the Hymenopteron shown in Fig. 77 are features suggestive of the Mecoptera, such as the one shown in Fig. 84. In fact, the Mecoptera are related to *both* Neuroptera and Hymenoptera, and have apparently inherited tendencies from both sources.

In many respects, the Hymenoptera are fully as primitive as the Neuroptera, and in certain features are even more primitive than the Neuroptera (e. g., nature of the genitalia, retention of cerci, etc.), and I am inclined to seek for the types ancestral to the Hymenoptera among the forms related to the Isoptera (with the Psocida and Zecraptera) on the one hand, and to the Coleoptera (with the Dermaptera) on the other. The mouthparts, however, do not furnish as instructive evidence as might be desired, since even in such primitive Hymenoptera as the one shown in Fig. 80, the mouthparts are quite highly modified. Even the larval mouthparts are very disappointing in this respect in the Hymenoptera, since they do not bear a striking resemblance to the mouthparts of any of the larvæ here figured, although one can detect a slight suggestion of affinities with the Coleoptera, on the one side, and with the Lepidoptera on the other. The Mecopterite shown in Fig. 19 is also disappointingly unlike any of the other insects figured, though it has a few features suggestive of affinities with the Trichoptera. It certainly is much more specialized than the primitive Neuroptera studied, and unless Dr. Tillyard can find some Mecopterite larva of a far more primitive character, he is not justified in assuming that the Mecopterous type is more primitive than the Neuropterous one (taking the group as a whole).

The evidence offered by the head structures is in full accord with the former contention (Crampton, 1920) that the Coleoptera are anatomically intermediate between the Dermaptera on the one side and the Neuroptera on the other, and this may have some bearing upon the question of the origin of the Neuroptera. Of the two groups (Coleoptera and Neuroptera) the Coleoptera are clearly the more primitive, with the exception of the feature of the highly modified fore wings. Other very lowly organized insects such as certain Blattidæ have fore wings quite as highly modified as the most primitive Coleoptera, however, and the fore wings of the Dermaptera are even more highly modified than those of the primitive Coleoptera, so that this feature is of no great importance in determining the relative primitiveness of a group of insects as a whole. The occurrence of the peculiar sclerite, "pst," found only in the maxillæ of Coleoptera (Fig. 4) and Dermaptera (Fig. 7), in addition to other features of resemblance in the two groups (e. g., the nature of the antennal segments, the segmentation of the cerci in certain immature Coleoptera and Dermaptera, the character of the thoracic terga, etc.)

indicates a close relationship between the Coleoptera and the Dermaptera. On the other hand, the occurrence in coleopterous and neuropterous larvæ of the peculiar type of maxillæ with both palp, "mp," and slender galea, "ga," borne on a slender segment-like structure, "ds," (see Figs. 23 and 27) in addition to other features of resemblance in the larvæ of the two groups (e. g., nature of the thoracic sclerites, etc.), indicates a close relationship between the Coleoptera and the Neuroptera. In fact, it is extremely difficult to discover any features which will distinguish a larval Coleopteron from a larval Neuropteron in every case, and certain coleopterous larvæ might readily be mistaken for neuropterous larvæ, so great is the similarity between the two groups. The Coleoptera, however, are the more primitive of the two orders (Neuroptera and Coleoptera) and serve to connect the Neuroptera with the insects related to the Dermaptera on the one side and with those related to the Isoptera (with the Zoraptera) on the other. In some respects, the Coleoptera are very like the Embiidæ, particularly in the nature of the head capsule and certain of the mouthparts, as may be seen by comparing Fig. 17 of a beetle with Fig. 18 of an embiid; and the "roots" of the Coleopteron line of development strike down deeply into the group of insects related to the Dermaptera (i. e., the Embiidæ and Plecoptera), some of the coleopterous features being even more primitive than these features in the Dermaptera although the Dermaptera as a whole are much more primitive than the Coleoptera.

The head region of certain Psocidæ (*sensu lato*) is very like that of some of the Neuroptera (and Hymenoptera also), particularly in the frontal region of the head. The fact that the head region of some Hemiptera (Corixidæ, etc.) overlaps the pronotum is a feature indicating a relationship to the Psocidæ, when taken in conjunction with other resemblances in the head capsule of the two groups (Hemiptera and Psocidæ). The type of head found in the Psocidæ was apparently derived from the Zorapteron type, which in turn was derived from a Plecopteron type (although the Zoraptera are undoubtedly related to the Isoptera as well). From the morphological standpoint alone, the line of development of the Hemiptera would therefore be suggested by the series Plecoptera, Zoraptera, Psocidæ, Homoptera (the Psyllidæ approach the Psocidæ in many respects) and Hemiptera. The Thysanoptera also approach the Psocidæ in many respects, and I have found a psocid whose head is very suggestive of the type leading to the Thysanopteron type, as will be brought out in a later publication. Not only does the typical psocid head approach the Neuropteron type in many respects, but the head of a sawfly also resembles both of these types very markedly and the evidence offered by a study of the head structures is quite in accord with the former contention (Crampton, 1920) that the Hymenoptera are anatomically intermediate between the Psocidæ and the Neuroptera.

THE HEAD CAPSULE OF THE NEUROPTERA.

Since the Neuroptera are an extremely important group from the standpoint of the study of the phylogeny of the higher insects, I have drawn as many types of neuropterous heads as I have been able to examine, in order that anyone wishing to find out what modifications of the head capsule are to be found in the group, may be able to determine which families give indications of being of value for a phylogenetic study. Furthermore, although a study of the head region alone is of no great value in determining the interrelationships of the members of the order Neuroptera, there are certain features of the head region which offer indications of relationship between certain insects, and the evidence of the head region should be added to that drawn from the study of other parts of the body, in attempting to determine the interrelationships of the families of Neuroptera.

The character of the mouthparts of the larval *Sialis* shown in Fig. 23 would indicate that *Sialis* is as primitive as any of the Neuroptera, and the head capsule in general (Fig. 40) of the larva is as primitive as any. The secondary marking off of the areas labeled "pcl" on either side of the clypeus of the larvæ of *Raphidia* and *Corydalidæ* (Figs. 41 and 42) represents a higher degree of specialization than is exhibited by the larva of *Sialis* (Fig. 40). On the other hand, the nature of the occipital region, "ocp," in the head region of the larvæ of *Raphidia* and *Corydalidæ* (Figs. 41 and 42) in addition to the presence of the peculiar sclerites, "pcl," in these larvæ indicates a rather close relationship between the two, and the line of development of the *Raphidiidæ* and *Corydalidæ* apparently quickly merge as we trace them back to that of the *Sialis* type. The head of a *Chauliodes* larva is so like that of a *Corydalidæ* larva that there is practically no difference between the two, and there can be no doubt that *Chauliodes* is extremely closely related to *Corydalidæ*. The head capsule of *Chauliodes* (Fig. 34) furnishes an excellent starting point in taking up the study of the head region of the higher Neuroptera, and it is approached by *Polystchoetes* and also by *Oliarces*, *Ithone* and other *Ithoniidæ* as closely as any other higher forms. *Oliarces*' head is remarkably similar to that of *Ithone*, as may be seen by comparing Fig. 53 with Fig. 52, and there can be no doubt that these two insects belong to the same family (*Ithoniidæ*) as is also true of *Raphisma*, although Tillyard in his monograph of the *Ithoniidæ* does not include these insects (*Oliarces* and *Raphisma*) in the family. Furthermore, the head capsule of the *Ithoniidæ* is remarkably like that of the primitive *Lepidoptera* and *Trichoptera* described by Crampton, 1920, and I am convinced that the *Lepidoptera* and *Trichoptera* were descended from ancestors very similar to those of the *Ithoniidæ*.

With regard to the relationships of the *Nemopteridæ*, which are of great interest from the fact that they approach the *Mecoptera* and *Diptera* in many respects, it must be admitted that the adult heads give but few clues as to their nearest relatives. The head structures of the *Nemopterid Croce*, however, have been figured by Imms, 1911, and indicate that the *Nemopterid* type was probably derived from forms

related to the Ascalaphidae and Myrmeleonidae. The head of a larval Ascalaphid (Fig. 47) is extremely similar to that of a larval Myrmeleonid (Fig. 44) and the head of an adult Myrmeleonid such as that shown in Fig. 70 is very like that of *Nymphes* (Fig. 72) even to the presence of the sense organ, "pm," in the labial palpi of both insects, so that the Nymphidae very probably represent the types ancestral to the Myrmeleonidae, etc.

The head and mouthparts of *Psychopsis* (Fig. 46) are somewhat intermediate between the Myrmeleonid type (Fig. 44) and the Hemerobiid type, which is extremely like that of the Chrysopidae (Fig. 51) and *Psychopsis* may, therefore, be regarded as a connecting link between the two groups. The head of an adult *Psychopsis* (Fig. 71) is very like that of the Myrmeleonid shown in Fig. 70, and so far as the evidence of the head alone is concerned, *Psychopsis* is quite close to the Myrmeleonids in many respects. Whether *Psychopsis* leads back through the Hemerobiid and Chrysopid type to the Ithoniid type of Neuropteran, I cannot say, since the head alone offers insufficient evidence upon which to base one's conclusions in this matter.

The head of *Nothochrysa* (Fig. 66) is extremely like that of *Apochrysa* (Fig. 67), while that of *Euporismus* (Fig. 68) has many features suggestive of affinities with *Stenosmylus* (Fig. 63). *Miodactylus* (Fig. 69) resembles *Stenosmylus* (Fig. 63) on the one hand and *Nymphes* (Fig. 72) or the Myrmeleonids, on the other. *Porismus* (Fig. 65) is quite like *Euporismus* (Fig. 68) in many respects, but also shows some points of resemblance to *Psectra* (Fig. 62). *Psectra* (Fig. 62) is very like *Sisyra* (Fig. 59) and *Climacea* (Fig. 60) also, and *Climacea* in turn bears a resemblance to *Conwenzia* (Fig. 61). *Osmylus* (Fig. 58) is obviously related to the other Osmylidae, Hemerobiidae, and Chrysopidae, but it also bears a resemblance to *Climacea* and *Conwenzia*. *Sisyra*, *Climacea*, *Conwenzia* and similar forms were probably derived from ancestors resembling the Ithoniidae (Figs. 52 and 53), a family which should include the genera *Oliarces* and *Rhapisma*, as well as *Ithone*, although *Oliarces* has never been included in the family (excepting by Crampton, 1920) despite the fact that its head is exactly like that of *Ithone* (compare Figs. 52* and 53) as is also true of the thoracic sclerites, etc.

Mantispa (Fig. 57) is a very peculiar form, and its affinities cannot be determined from the adult head alone. Its head resembles that of *Chrysopa*, in some respects, and its closest affinities may be with these insects. On the other hand, the head of *Mantispa* exhibits some similarities to the head of *Nemoptera*, although these resemblances are probably more superficial. The resemblance to the head of *Conwenzia* is more marked, and it is possible that *Mantispa* may be related to both *Chrysopa* and *Conwenzia*.

* Dr. Tillyard has very kindly given me some specimens of *Ithone* preserved in alcohol, and an examination of this material (made after this paper had been prepared) would indicate that the labial region in Figs. 52 and 53 was so distorted as to be quite "unnatural" in the dried specimens from which the drawings were made.

SUMMARY.

The principal structures of the head, the sclerites of the head capsule, and the subdivisions of the mouthparts may be briefly summarized in the following table in which the relations of the parts to one another are also shown.

	{	Occiput.....	Trophiger	
	{	Parietals.....	{	Postcranials
			{	Vertex
			{	Adfrontals
Epicranium.....	{		{	Parafrons
	{	Facies.....	{	Frons.....
			{	Antefrons.....
			{	Postfrons
			{	Anteclypeus
			{	Postclypeus
	{	Laterocranium	{	Genæ, with Basimandibula
			{	Postgenæ.....
			{	Hypostoma
			{	Paragula
Gulamentum.....	{	Gula		
	{	Submentum		
Mentum				
Eulabium.....	True labium....	{	Labial palpi	
			Palpiger	
			Labiosternite	
			Labiostipes	
			Ligula.....	{
				Glossæ
				Paraglossæ
Maxilla.....	{	Basimaxilla		
	{	Maxillary	{	Cardo.....
		palpus	{	Eucardo
		Body of	{	Paracardo
		maxilla	{	Eustipes.....
			{	Stipes.....
			{	Parastipes
			{	Dististipes
				Proxistipes
				Basistipes
			Palpifer	
			Galea	
			Lacinia	
Mandible				
Labrum.....	{	Antelabrum		
	{	Postlabrum		
Epipharynx				
Hypopharynx.....	{	Lingua		
	{	Paragnaths (parts of maxilla associated with hypopharynx)		
Endoplicæ				
Tentorium.....	{	Body of tentorium		
	{	Frontal plate of tentorium		
	{	Dorsal anterior arms		
	{	Ventral Anterior arms		
	{	Posterior arms		

A study of the embryological development of the head of an insect and a comparison with the head region of the Crustacea (which are like the ancestors of insects) would indicate that six primitive segments enter into the composition of the head of an insect. The protocephalon, antennal, intercalary, mandibular, first maxillary, and second maxillary (labial) segments of an insect's head correspond to the protocephalon, antennular, antennal, mandibular, first maxillary, and second maxillary segments, respectively, in a crustacean's head. The so-called "superlinguæ" of insects are homologous with the paragnaths, not with the "maxillulæ" (first maxillæ) of Crustacea. The mandible of an insect represents only one (the basal) segment of a crustacean's limb, while the body of the maxilla of an insect is composed of several segments of such a limb, so that the parts of an insect's maxilla are not represented in the mandible.

In conjunction with other structures of the body, the head region of insects furnishes indications of a relationship to the Crustacea on the one side, and to the Symphyla on the other. *Machilis* among the Apterygota, and the ephemerids among the Pterygota have retained a number of features suggestive of affinities with the Crustacea, and the head region of *Machilis* would indicate that it is an extremely ancient type related to such forms as *Lepisma Nicoletia*, etc. (and also to *Japyx* and *Campodea*) on the one hand, and to the Collembola on the other. The head of *Machilis*, *Lepisma* and *Nicoletia* among the Apterygota have more suggestions of crustacean affinities, while the head of *Japyx* and *Campodea* is very like that of *Scolopendrella* and other Symphyla-like forms.

Lepisma offers a connecting link between *Machilis* (which leads to the crustacean forms) and the lower winged insects such as the Plecoptera, ephemerids, etc., and the head of immature Plecoptera approach as closely as any type, to that of *Lepisma*. The head of an immature Plecopteron on the other hand, is extremely similar to that of *Arixenia* among the Dermaptera. The head structures of the Dermaptera (and the Embiidæ also) in turn lead to the type found in Coleoptera, particularly in the structure of the maxillæ. As we trace the head types from the Coleoptera upward, the Neuroptera appear to be the next of kin, since the head structures of larval Coleoptera and Neuroptera are astonishingly alike. The Neuroptera

in turn lead to the Mecoptera, Diptera, and Siphonaptera, on the one hand, and to the Trichoptera and Lepidoptera on the other, the neuropterous head which most resembles the head of the Mecoptera and Diptera being that of *Nemoptera*, while the neuropterous head which most resembles that of the Trichoptera (such as *Philopotamus*) and Lepidoptera (such as the micropterygids) is the head of *Oliarces* and other Ithoniidæ.*

The head of a Zorapteron is intermediate between that of certain Plecoptera such as *Capnia*, *Leuctra*, etc., and the Psocid type. Certain of the Psocidæ, in turn, have elongate heads suggestive of affinities with the Thysanoptera, while others exhibit undoubted affinities with the Homoptera and Hemiptera. The head of a mallophagan was undoubtedly derived from the psocid type, and the head structures of the Pediculidæ exhibit affinities with the Mallophaga, etc., as well.

The head structures of Hymenoptera are rather puzzling. They exhibit features suggestive of the Mecoptera on the one side, and with the Neuroptera, as well as the Zoraptera and Psocidæ, on the other. The Psocidæ likewise exhibit certain features very suggestive of a relationship to the Neuroptera, and there is apparently a rather complicated interrelationship between these groups, as is shown in the head structures as well as in other features of the body, such as the ovipositor, etc. In certain respects, the head structures of Hymenoptera (even of the sawflies) are rather highly modified, but the sawfly type is a far more ancient one than it is commonly supposed to be, and probably arose from ancestors intermediate between the Zoraptera (with the Isoptera) on the one side, and the Coleoptera (with the Dermaptera) on the other.

The study of the head and its appendages has shown that these structures are of prime importance for a study of the interrelationships and phylogeny of insects, and before we can arrive at the correct conclusion concerning the evolution of the various orders, and the origin of the Hexapoda, it will be neces-

*The Hemiptera (and Homoptera) are related not only to the Psocidæ, but to the Lepidoptera, Mecoptera, and Neuroptera, as well and exhibit many features suggestive of affinities with the Lepidoptera and Mecoptera. The lines of development of these forms apparently arose at the point where the Neuroptera and Psocidæ began to diverge, and therefore took over in their development, features common to both. Under these conditions it is readily seen that the Lepidoptera may resemble the Psocidæ and Hemiptera (Homoptera) on the one side, and the Neuroptera, etc., on the other, and this fact has not been sufficiently emphasized by students of insectan phylogeny.

sary to make a detailed study of the head, neck plates, thoracic sclerites and appendages, and the terminal abdominal structures, if the results are to be based upon a firm foundation, since any view based upon the study of the wings alone, and not supported by the evidence drawn from the study of other parts of the body as well, can be accepted only with reservation. So far as the study of the origin of insects and their immediate relatives is concerned, I have found the head structures, and the mandibles in particular, to be of the greatest value; and the study of the head structures in the various orders of insects promises to be of equal importance in determining the inter-relationships of insects themselves.

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ABBREVIATIONS.

ac.....anteclypeus.	lg.....ligula.
af.....adfrons.	lp.....labiopalpus (labial palp).
anf.....antennifer.	ls.....labiostipes.
ant.....antennæ.	m.....myocicatrix.
ap.....labiappendices.	md.....mandible.
bat.....basantenna.	mgs.....midgular suture.
bg.....basigalea.	mn.....mentum.
bl.....basilacinia.	mp.....maxillipalpus (maxillary palp).
bm.....basimaxilla.	mx.....maxilla.
bmd.....basimandibula.	oc.....ocelli.
bs.....stipes, or its basal portion.	ocp.....occiput.
ca.....cardine angle.	pa.....parietals.
car.....cardo.	pac.....paracardo.
cl.....clypeus.	pas.....parastipes.
cs.....coronal suture.	pc.....postclypeus.
dg.....distigalea.	pcl.....paraclypeus ("jugum?").
ds.....palparium, or palpifer.	pf.....parafrons.
ec.....epicondyle.	pfr.....palpifer (in some cases basal segment of palp?).
eps.....epistoma.	pg.....paraglossæ.
euc.....eucardo.	pgr.....palpiger.
eus.....eustipes.	pgu.....paragula.
f.....laciniafimbrium.	pm.....palpimacula.
fp.....frontal pits.	poc.....postorbital crest.
fr.....frons.	prg.....pregula.
fs.....frontal suture.	prm.....basilabrum (premental plate).
g.....galeafimbrium.	ps.....laterocranial (paracephal) sutures.
ga.....galea.	pst.....basistipes.
ge.....gena.	sa.....stipital angle.
gg.....galeafer (possibly palpifer).	sar.....sensarea.
gl.....glossa.	se.....sensorium.
gp.....gular pits.	sm.....submentum.
gu.....gula.	sml.....submentales.
hc.....hypocondyle.	so.....sense organ.
hs.....hypostoma.	spt.....spinneret.
in.....dististipes.	sti.....stipes.
is.....intersternite (postgula).	stm.....stemmata (larval "ocelli").
l.....labrum.	x.....attachment of stipital plica.
la.....lacinia.	
lc.....lacinial cleft.	

MUSCLES.

- | | |
|------------------------------------|-----------------------------------|
| 1. tentorio-intramaxillary muscle. | 7. tentorio-galeal muscle. |
| 2. tentorio-stipital muscle. | 8. stipito-palpal muscle. |
| 3. tentorio-paracardine muscle. | 9. tentorio-labiostipital muscle. |
| 4. tentorio-eucardine muscle. | 10. tentorio-palpiger muscle. |
| 5. paragulo-cardine muscle. | 11. submento-menta' muscles. |
| 6. paragulo-stipital muscle. | |

EXPLANATION OF PLATES.

(Unless otherwise stated, all Figures are of adult insects).

PLATE II.

- Fig. 1. Posterior view of right maxilla of *Chauliognathus marginatus* (Coleoptera).
- Fig. 2. Posterior view of right maxilla of *Corydalis cornutus* (Neuroptera).
- Fig. 3. Posterior view of right maxilla of *Harpalus* (Coleoptera).
- Fig. 4. Posterior view of right maxilla of *Necrophorus* (Coleoptera).
- Fig. 5. Posterior view of head of larval Silphid (Coleoptera).
- Fig. 6. Posterior view of head of *Gryllus* (Orthoptera).
- Fig. 7. Posterior view of head of *Arixenia* (Dermaptera).
- Fig. 8. Posterior view of head of larval Pyrochroid (Coleoptera).
- Fig. 9. Posterior view of head of larval *Tenebrio* (Coleoptera).
- Fig. 10. Posterior view of head of *Periplaneta orientalis* (Blattida).

PLATE III.

- Fig. 11. Posterior view of head of *Corydalis* (Neuroptera).
- Fig. 12. Posterior view of head of larval *Raphidia* (Neuroptera).
- Fig. 13. Posterior view of head of alate *Termopsis* (Isoptera).
- Fig. 14. Posterior view of head of larval *Corydalis* (Neuroptera).
- Fig. 15. Posterior view of head of larval *Corydalis* (Neuroptera).
- Fig. 16. Posterior view of head of *Termopsis* soldier (Isoptera).
- Fig. 17. Posterior view of head of *Harpalus* (Coleoptera).
- Fig. 18. Posterior view of head of *Embia major* (Embiidina).
- Fig. 19. Posterior view of larval *Panorpa* (Mecoptera).

PLATE IV.

- Fig. 20. Posterior view of mouthparts of larval *Limnephilid* (Trichoptera).
- Fig. 21. Posterior view of mouthparts of larval *Psilotreta* (Trichoptera).
- Fig. 22. Posterior view of head of larval Elaterid (Coleoptera).
- Fig. 23. Posterior view of mouthparts of larval *Sialis* (Neuroptera).
- Fig. 24. Posterior view of mouthparts of larval *Polycentropid* (Trichoptera).
- Fig. 25. Posterior view of mouthparts of larval *Prionyxus* (Lepidoptera).
- Fig. 26. Posterior view of mouthparts of larval *Rhyacophila* (Trichoptera).
- Fig. 27. Posterior view of head of larval *Hydrophilus* (Coleoptera).
- Fig. 28. Posterior view of right maxilla of larval *Schizura concinna* (Lepidoptera).
- Fig. 29. Posterior view of head of larval *Achroia grisella* (Lepidoptera).
- Fig. 30. Posterior view of mouthparts of larval *Cimbex* (Hymenoptera).
- Fig. 31. Posterior view of mouthparts of larval *Hepialus* (Lepidoptera).

PLATE V.

- Fig. 32. Frontal view of head of larval *Neurotoma* (Hymenoptera).
- Fig. 33. Frontal view of head of *Raphidia* (Neuroptera).
- Fig. 34. Frontal view of head of *Chauliodes* (Neuroptera).
- Fig. 35. Frontal view of head of *Sialis* (Neuroptera).
- Fig. 36. Frontal view of head of *Anisolabis maritima* (Dermaptera).
- Fig. 37. Frontal view of head of male *Corydalis* (Neuroptera).
- Fig. 38. Dorsal view of head of larval *Chalcophora* (Coleoptera).
- Fig. 39. Frontal view of head of alate *Mastotermes darwinensis* (Isoptera).
- Fig. 40. Frontal view of head of larval *Sialis* (Neuroptera).
- Fig. 41. Frontal view of head of larval *Raphidia* (Neuroptera).
- Fig. 42. Frontal view of head of larval *Corydalis* (Neuroptera).

PLATE VI.

- Fig. 43. Frontal view of head of *Berolha piepersii* (Neuroptera).
- Fig. 44. Posterior view of mouthparts of larval *Myrmelionid* (Neuroptera).
- Fig. 45. Frontal view of head of *Polystochoetes* (Neuroptera).
- Fig. 46. Posterior view of mouthparts of larval *Psychopsis elegans* (Neuroptera).
- Fig. 47. Posterior view of mouthparts of larval Ascalaphid (Neuroptera).
- Fig. 48. Frontal view of head of *Dilar corsicus* (Neuroptera).
- Fig. 49. Posterior view of head of larval *Megaxyela* (Hymenoptera).
- Fig. 50. Ventral view of head of larval *Climacea* (Neuroptera).
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- Fig. 52. Frontal view of head of *Ithone fusca* (Neuroptera).
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- Fig. 54. Posterior view of head of larval *Neurotoma* (Hymenoptera).
- Fig. 55. Posterior view of head of larval *Cowenzia hageni* (Neuroptera).
- Fig. 56. Frontal view of head of *Nemoptera sinuata* (Neuroptera).
- Fig. 57. Frontal view of head of *Mantispa pagana* (Neuroptera).

PLATE VII.

- Fig. 58. Frontal view of head of *Osmylus maculatus* (Neuroptera).
- Fig. 59. Frontal view of head of *Sisyra* (Neuroptera).
- Fig. 60. Frontal view of head of *Climacea* (Neuroptera).
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- Fig. 62. Frontal view of head of *Psectra dipterum* (Neuroptera).
- Fig. 63. Frontal view of head of *Stenosmylus tenuis* (Neuroptera).
- Fig. 64. Frontal view of head of *Chrysopa perla* (Neuroptera).
- Fig. 65. Frontal view of head of *Proismus strigatus* (Neuroptera).
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- Fig. 68. Frontal view of head of *Euporismus albatrox* (Neuroptera).
- Fig. 69. Frontal view of head of *Miodactylus pubescens* (Neuroptera).
- Fig. 70. Frontal view of head of *Acanthaclistes americana* (Neuroptera).
- Fig. 71. Frontal view of head of *Psychopsis insolens* (Neuroptera).
- Fig. 72. Frontal view of head of *Nymphes* (Neuroptera).
- Fig. 73. Frontal view of head of *Ululodes* (Neuroptera).
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PLATE VIII.

- Fig. 75. Posterior view of labium of *Cicada* (Homoptera).
- Fig. 76. Lateral view of head of *Belostoma* (Hemiptera).
- Fig. 77. Posterior view of mouthparts of *Bracon liberator* (Hymenoptera).
- Fig. 78. Frontal view of head of *Macroxyela* (Hymenoptera).
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- Fig. 80. Posterior view of mouthparts of *Macroxyela* (Hymenoptera).
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- Fig. 82. Posterior view of labium of *Panorpa lugubris* (Mecoptera).
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